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(*Recognosce notum, ignotum inspice*)

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J. RAMSBOTTOM, B. BARNES and H. WORMALD

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THE BECCLES FORAY

28–31 May 1937

BY C. G. C. CHESTERS

ABOUT thirty members and friends assembled at Beccles for the spring foray of 1937 which was held during the week-end of 28–31 May, with headquarters at the White Lion Hotel, Beccles, Suffolk.

At an informal meeting on Friday evening Mr G. J. Cooke gave an interesting account of the mycologists who had lived or worked in the neighbourhood of Beccles. Thereafter he and Mr E. A. Ellis described the arrangements which had been made for the excursions during the week-end.

Saturday's excursion was to Fritton Lake and the party left the White Lion by bus at about 10 a.m. This lake "was traditionally known as Gunhilde's Mere, from Gunhilda, a beautiful Christian woman and sister to Sweyne the Danish pirate, who was the father of King Canute". It is a part of that pre-Roman estuary which opened to the sea between the cliffs at Caister and Gorleston. Many of the party were interested in the decoy which was shown them by the keeper, who explained the manner in which the decoy is used to capture wild duck on the lake. The previous dry spell made collecting in the coniferous and deciduous woods rather poor, but *Hydnum auriscalpium* was welcomed as an old friend. A fine specimen of *Reticularia Lycoperdon* was observed on the trunk of a tree, well out of reach. *Diatrypella quercina* was collected on *Castanea*, which is not an altogether common host for this species in Britain. Lunch was taken by the side of the lake, where the abundance of *Diatrypella favacea* on *Alnus* was most noticeable. After further work, the party was conveyed by bus to the opposite side of the lake where the woods were explored on the way to tea at the Old Hall Farm. During the walk, excellent specimens of *Diatrype Stigma*, with its conidial stage, *Libertella betulina*, were collected on *Betula*. During the day Mr Pearson collected *Protohydnum lividum* Bres. = *Protodontia uda* v. Höhnel & Litsch. and has communicated the following note: "The last named was found on rotten wood of both pine and of a deciduous tree, the spores being always broadly ovate, 5–6 × 4–4·5 μ, uniguttulate or filled with a granular substance, minutely apiculate. In the previous British record the spores were elliptical 6–8 × 3–4 μ, and our specimens might be considered as a different species. But, as defined by Bourdot & Galzin (*Hymenomycetes de France*, p. 34) the spores are 5–9 × 4–6 μ. Our specimens come within this wide range."

The party visiting Worlingham Hall on Sunday, started at 11 o'clock from the White Lion by private cars. The day was

particularly hot and the woods very dry, but several resupinates were collected on fallen wood, as well as a few rusts. During the evening, some members explored the waterways near Beccles and collected *Protomyces macrosporus* and the very abundant *Plasmopara nivea*. *Puccinia Smyrnii* was extremely common and in excellent condition.

Blythburgh and Walberswick were visited by bus on Monday and, on the way, Fen Covert was explored. These woods are deciduous and rather marshy. *Russula claroflava*, growing amongst moss under birch trees, and several other larger fungi were noted. *Puccinia Le Monnieriana* was collected by Dr Smith. *Anthostoma dryophilum* on fallen oak was an interesting find. This fungus is probably more widespread than its records suggest, but it never occurs in great quantity in any one place. After lunch, some hawthorns were observed heavily infected by *Monilia Crataegi*. This fungus was also found at Fritton. The heavy, sweet scent is characteristic. This year *M. Crataegi* has been particularly common.

At Walberswick the ditches provided good specimens of *Puccinia Magnusiana* with aecidia on *Ranunculus* and teleutosori on *Phragmites*, while on the salt marsh several plants of *Statice Limonium* infected by *Uromyces Limonii* were observed.

At a meeting held during the week-end it was decided that, if possible, the Spring Foray for 1938 should be held at Chipping Campden. At the close of the meeting, hearty votes of thanks were accorded to landowners whose estates had been visited during the week-end. Special thanks were accorded to Mr G. J. Cooke, Mrs Cooke and Mr E. A. Ellis for the local arrangements so splendidly made for the profit and comfort of the party.

The Secretary is indebted to all members present for records from which the attached list of species is compiled. The list of Mycetozoa is mainly based on records supplied by Mr E. A. Ellis, and the list of lichens on records supplied by Mr Manning and Mr Burn.

List of species gathered during the Foray

F. = Fritton Lake Area; *W.* = Worlingham Hall; *Bl.* = Blythborough District; *Wl.* = Walberswick District; *B.* = Beccles neighbourhood.

HYMENOMYCETES

Pluteus cervinus (Schaeff.) Fr., *F.*, *W.*, leoninus (Schaeff.) Fr., *W.*
Psaliota campestris (Linn.) Fr., *F.*
Armillaria mellea (Vahl) Fr., rhizomorphs only, *F.*, *W.*
Pholiota praecox (Pers.) Fr., *F.*, *W.*, *B.*, aegerita (Porta) Fr., *Wl.*, erinacea (Fr.) Quél., *Bl.*, mutabilis (Schaeff.) Fr., *F.*
Inocybe lacera Fr., *F.*
Entoloma lividum (Bull.) Fr., *W.*, *Bl.*, clypeatum (Linn.) Fr., *W.*
Hypholma fasciculare (Huds.) Fr., *W.*
Laccaria laccata (Scop.) B. & Br., *W.*
Flammula sapinea Fr., *F.*

Collybia platyphylla (Pers.) Fr., *F.*, leucomyosotis Cke. & Smith, *F.*, *W.*
Panaeolus sphinctrinus Fr., *B.*, papilionaceus (Bull.) Fr., *F.*
Mycena leptocephala (Pers.) Fr., *W.*, Iris Berk., *F.*, *W.*, vitilis Fr., *F.*, *Bl.*, acicula (Schaeff.) Fr., *W.*
Nolanea proletaria Fr., *F.*
Galera hypnorum (Schrank) Fr., *F.*
Psathyrella disseminata (Pers.) Fr., *F.*
Omphalia umbellifera (Linn.) Fr., *F.*
Tubaria paludosa Fr., *F.*, stagnina Fr., *W.*
Pleurotus ostreatus (Jacq.) Fr., *Bl.*, *B.*
Schizophyllum commune Fr., *Wl.*
Russula fragilis (Pers.) Fr., *Bl.*, claroflava (Grove) Cke., *F.*, *Bl.*
Lactarius rufus (Scop.) Fr., *F.*
Bolbitius vitellinus (Pers.) Fr., *W.*
Coprinus atramentarius (Bull.) Fr., *W.*, micaceus (Bull.) Fr., *W.*
Marasmius peronatus (Bolt.) Fr., *Bl.*, oreades (Bolt.) Fr., *F.*, esculentus (Wulf.) Karst., *F.*, *W.*, dryophilus (Bull.) Karst., *Bl.*, var. funicularis (Fr.) Rea, *W.*
Polyporus varius Fr., *F.*, *W.*, squamosus (Huds.) Fr., *B.*, sulphureus (Bull.) Fr., *F.*, betulinus (Bull.) Fr., *F.*, *W.*, hispidus (Bull.) Fr., *W.*, adustus (Willd.) Fr., *F.*
Fomes annosus Fr., *F.*, *W.*
Ganoderma applanatum (Pers.) Pat., *W.*
Polystictus versicolor (Linn.) Fr., *B.*, *F.*, *W.*, *Bl.*
Irpex obliquus (Schrad.) Fr., *F.*, *Bl.*
Coniophora puteana (Schum.) Karst., *B.*
Fistulina hepatica (Huds.) Fr., *F.*
Hydnum auriscalpium (Linn.) Fr., *F.*
Protohydnum lividum Bres. = Protodontia uda v. H. & Litsch., *F.*
Grandinia farinacea (Pers.) Bourd. & Galz., *F.*, *W.*, helvetica (Pers.) Fr., *W.*
Odontia bicolor (A. & S.) Bres., *F.*, *W.*, papillosa (Fr.) Bres., *W.*, arguta (Fr.) Quél., *F.*
Hypochnus fuscus (Pers.) Fr., *F.*, fumosus Fr., *F.*
Stereum hirsutum (Willd.) Fr., *F.*, *W.*, Chailletii (Pers.) Fr., *W.*
Corticium laeve (Pers.) Quél., *F.*, *Bl.*, Galzinii Bourd., *F.*, *Bl.*, arachnoideum Berk., *Bl.*, Sambuci (Pers.) Fr., *W.*, subcoronatum v. H. & Litsch., *F.*, comedens (Nees) Fr., *F.*, (Gloeo.) porosum Berk. & Curt., *W.*, (Gloeo.) praetermissum (Karst.) Bres., *W.*, (Gloeo.) lactescens Berk., *F.*
Peniophora pallidula Bres. ex Bourd. & Galz., *W.*, byssoidea (Pers.) v. H. & Litsch., *F.*, longispora (Pat.) v. H. & Litsch., *W.*, cremea Bres., *F.*, velutina (DC.) Cke., *F.*, *W.*, hydnoides Cke. & Mass., *F.*, *W.*, incarnata (Pers.) Cke., *F.*, cinerea (Fr.) Cke., *W.*, quercina (Pers.) Cke., *W.*
Auricularia mesenterica (Dicks.) Fr., *W.*, auricula-Judae. (Linn.) Schroet., *F.*
Exidia glandulosa (Bull.) Fr., *B.*

GASTEROMYCETES

Phallus impudicus (Linn.) Pers., *F.*, *W.*
Lycoperdon caelatum (Bull.) Fr., *Bl.*, depressum Bon., *Bl.*, perlatum Pers., *Bl.*
Bovista nigrescens Pers., *W.*, plumbea Fr., *Bl.*, *Wl.*
Geaster fimbriatus, Fr., *W.*

UREDINALES

Uromyces Limonii (DC.) Lév., *Wl.*, Scillarum (Grev.) Wint., *F.*
Puccinia Violae (Schum.) DC., *W.*, Malvacearum Mont., *B.*, *F.*, *Bl.*, Conii (Str.) Fuck., *W.*, Smyrnii Biv., *B.*, *Bl.*, *Wl.*, obtegens (Link) Tul., *Wl.*, Hypochaeridis Oud., *B.*, obscura Schroet., *F.*, Caricis (Schum.) Rebent., *B.*, *F.*, *W.*, Schoeleriana Plowr. & Magn., *Bl.*, Bromina Erikss., *B.*, simplex (Koern.) Erikss. & Henn., *B.*, Magnusiana Koern., *Wl.*, Le Monnieriana Maire, *Bl.*
Phragmidium violaceum (Schultz) Wint., *F.*

USTILAGINALES

Ustilago longissima (Sow.) Wint., *B.*, violacea (Pers.) Wint., *B.*, striiformis (Westen.) Niess., *B.*

PYRENOMYCETES

Sphaerotheca pannosa (Wallr.) Lév., *B.*
Podosphaera Oxyacanthae (DC.) de Bary, *B.*
Bertia moriformis (Tode) de Not., *F.*
Melanomma Pulvis-pyrius (Pers.) Fuckel, on *Betula*, *W.*
Mycosphaerella Rhododendri (Cooke) Lind., on leaves of *Rhododendron*, *F.*, punctiformis (Pers.) Schröter, *W.*
Venturia Rumicis (Desm.) Wint., *W.*, *Bl.*
Laestadia Rhodorae (Cooke) Berk. & Vogl., on leaves of *Rhododendron*, *F.*
Leptosphaeria acuta (Moug.) Karst., on *Urtica*, *F.*
Diaporthe leiphemia (Fr.) Sacc., on *Quercus*, *W.*, *Bl.*
Melanconis stilbostoma (Fr.) Tul., on *Betula*, *F.*
Pseudovalsa lanciformis (Fr.) Ces. & de Not., on *Betula*, *W.*
Diatrype Stigma (Hoffm.) Fr., on *Ilex*, *F.*, on *Betula* (with its conidia, Libertella betulina Desm.), *F.*, ("Eutypa lata" condition) *W.*, disciformis (Hoff.) Fr., on *Fagus*, *F.*, on *Salix*, *W.*
Diatrypella quercina (Pers.) Nitschke, on *Quercus* and *Castanea*, *F.*, on *Quercus*, *Bl.*, favacea (Fr.) Ces. & de Not., on *Betula*, *F.*, *Bl.*, on *Alnus* (=D. Tocciaeana de Not.) *F.*, *Bl.*, on *Fagus* (=D. nigro-annulata (Grev.) Nitschke), *F.*, *Bl.*
Anthostoma dryophilum (Curr.) Sacc., on *Quercus*, *Bl.*
Ustulina vulgaris Tul., on *Betula*, *F.*, *W.*
Hypoxylon multiforme Fr., on *Betula*, *F.*, *W.*, *Bl.*, on *Alnus*, *F.*, *W.*, on *Pyrus Aucuparia*, *F.*, serpens (Pers.) Fr., on *Fraxinus*, *F.*, *W.*, semi-immersum Nitschke, on *Corylus*, *F.*, rubiginosum (Pers.) Fr., on *Fraxinus*, *F.*, fuscum (Pers.) Fr., on *Corylus* and *Alnus*, *F.*, *W.*
Daldinia concentrica (Bolt.) Ces. & de Not., *Bl.*
Xylaria hypoxylon (Linn.) Grev., on *Fraxinus*, *F.*, polymorpha (Pers.) Grev., (conidial), *W.*
Hyponectria Buxi (Desm.) Sacc., on *Buxus*, *F.*
Nectria cinnabarina (Tode) Fr., on *Ilex*, *F.*, punicea (K. & Schm.) Fr., on *Ilex* and *Fagus*, *F.*, Coryli Fuckel, on *Salix*, *Bl.*, mammoidea, var. Rubi Weese, on *wild raspberry*, *W.*
Dialonectria Peziza (Tode) Cooke, on *Ilex*, *F.*
Hypomyces aurantius (Pers.) Tul., on *Polystictus versicolor* and *Polyporus adustus*, *F.*
Hypocrea pulvinata Fuckel, on *Polyporus betulinus*, *F.*
Epichloe typhina (Pers.) Tul., *F.*
Phyllachora Junci (Fr.) Fuckel, *Bl.*
Rhopographus filicinus (Fr.) Nitschke, *F.*, *W.*

DISCOMYCETES

Aleuria cerea (Sow.) Gill., *F.*
Ciliaria scutellata (Linn.) Quél., *W.*
Exoascus turgidus Sadeb., *F.*
Orbilia xanthostigma Fr., *F.*, *W.*
Sclerotinia Curreyana (Berk.) Karst., (sclerotia), *Bl.*
Chlorosplenium aeruginosum (Oeder.) de Not., (mycelium), *F.*
Belonopsis excelsior (Karst.) Rehm., on *Phragmites*, *F.*
Dasyscypha virginea (Batsch) Fuckel, *F.*, *W.*, *Bl.*
Trichoscypha calycina (Schum.) Boud., *W.*
Mollisia cinerea (Batsch) Karst., *F.*, *W.*
Pseudopeziza Cerastiorum (Wallr.) Fuckel, *W.*
Coccomyces Pini (A. & S.) Karst., on *Pinus*, *F.*
Colpoma quercinum (Pers.) Wallr., *W.*
Rhytisma acerinum (Pers.) Fr., *W.*

HYSTERIALES

Lophodermium arundinaceum (Schrad.) Chev., *F.*
Gloniopsis curvata (Fr.) Sacc. on *Rubus* and *Rosa*, *W.*

PHYCOMYCETES

Protomyces macrosporus Unger, *B.*
Plasmopara nivea (Unger) Schroet., *B.*, *W.*

DEUTEROMYCETES

Septoria Rosae Desm., *B.*
Leptostroma filicinum Fr., *W.*
Monilia candicans Sacc., on *rotten wood*, *Bl.*, Crataegi Died., on leaves of *Crataegus*, *F.*, *Bl.*
Cephalosporium verticicolum Petch on *Lycogala epidendrum*, *F.*
Acremonium album Preuss, on *Trichia varia*, *F.*
Rhinotrichum repens Preuss, *W.*
Ovularia obliqua (Cke.) Oud., *F.*, *B.*
Botrytis cinerea Pers., on *burnt Ulex*, *B.*
Ramularia Primulae Thüm., *W.*, Cirsii Allesch., *B.*, Hypochaeridis Magn., *B.*, Taraxici Karst., *B.*
Stachybotrys atra Corda, *B.*
Cercospora Mercurialis Passer., *W.*
Coniothecium effusum Corda, on *Alnus*, *Bl.*
Tilachlidium tomentosum (Schrad.) Lind., on *Trichia varia*, *F.*
Spicaria (Isaria) farinosa (Holms.) Petch, *F.*

MYCETOZOA

Rhynchosporium graminicola Hein., on *Hordeum*, *Bl.*
Ceratiomyxa fruticulosa (Muell.) Macbr., *F.*, *W.*
Physarum nutans Pers., *F.*
Fuligo septica (L.) Gmel., *F.*, *W.*
Craterium minutum (Leers) Fr., *F.*
Stemonites fusca Roth., *F.*, ferruginea Ehrenb., *F.*
Comatricha typhoides (Bull.) Rost., *F.*
Cribraria argillacea Pers., *W.*
Reticularia Lycoperdon Bull., *F.*
Lycogala epidendrum Fr., *F.*, *W.*, *B.*
Trichia persimilis Karst., *F.*, *W.*, varia Pers., *F.*, decipiens (Pers.) Macbr., *F.*, *W.*
Arcyria denudata Wettst., *F.*, *W.*, incarnata Pers., *Bl.*, pomiformis (Leers) Rost., *W.*

LICHENS

Cyphelium inquinans Trew., *F.*, *W.*, *Wl.*
Peltigera canina Willd., *F.*, *W.*, polydactyla Hoffm., on *Fraxinus*, *F.*
Parmelia physodes, f. labrosa Ach., *F.*, *W.*, and var. tubulosa Mudd., *F.*, perlata Ach., *F.*, *W.*, caperata Ach., *F.*, *W.*, sulcata Tayl., *F.*, acetabulum Dub., *W.*, exasperata Carroll, *F.*, fuliginosa var. laetevirens Nyl., *F.*, *W.*
Evernia prunastri Ach., *F.*, *W.*, *B.*
Ramalina fraxinea Ach., *B.*, fastigiata Ach., *F.*, farinacea Ach., *F.*, *W.*, *B.*
Usnea florida Web., *W.*
Xanthoria parietina Th. Fr., *F.*, *W.*, *Wl.*, *B.*, lychnea Th. Fr., *W.*, polycarpa Oliv., *F.*, *W.*, *Wl.*
Placodium murorum DC., *F.*, *W.*, *B.*, *Wl.*, citrinum Hepp., *W.*, *B.*, phloginum A. L. Sm., *B.*, *Wl.*
Candelariella vitellina Müll-Arg., *F.*, *W.*

Physcia ciliaris DC., *W.*, pulverulenta Nyl., *W.*, grisea Zahlbr., *F.*, *W.*, *Wl.*, hispida Tuckerm., *F.*, *B.*, elaeina A. L. Sm., *Wl.*, orbicularis var. virella Dalla Torre & Sarnth., *F.*, *W.*

Lecanora subfusca Ach., *F.*, *W.*, var. chlarona Ach., *F.*, *W.*, var. pinastre Schaer., *F.*, atra Ach., *F.*, *W.*, *B.*, *Wl.*, Hageni Ach., *Wl.*, carpinea Wain., *W.*, galactina Ach., *F.*, *W.*, *B.*, *Wl.*, farinaria Borr., *F.*, var. conizaeoides A. L. Sm., *F.*, *W.*, *B.*, *Wl.*, calcarea Sommerf., *B.*

Pertusaria faginea Leight., *F.*, *W.*, pertusa Dalla Torre & Sarnth., *F.*, *W.*, leioplaca Schaer., *F.*, *W.*

Phlyctis argenna Koerb., *F.*, *W.*

Cladonia foliacea Willd., *F.*, fimbriata Fr., *F.*, *W.*, var. simplex Wain., *F.*, *W.*, var. subcornuta Nyl., *F.*, rangiformis Hoffm., *F.*, macilenta Hoffm., *F.*, *W.*, macilenta var. ostreata Nyl., *F.* Floerkeana var. carcata Wain., *F.*

Lecidea uliginosa Ach., *F.*, immersa Ach., *B.*, dubia Turn. & Borr., *F.*, *W.*, parasema Ach., *F.*, *W.*, *Wl.*, crustulata Koerb., *F.*

Biatorina Griffithii Massal., *F.*, *W.*, *B.*

Buellia canescens De Not., *F.*, *W.*, *B.*, *Wl.*, myriocarpa Mudd., *F.*, *W.*

Arthonia radiata var. Swartziana Sydow, *F.*, *W.*

Opegrapha atra Pers., *F.*, *W.*, vulgata Ach., *F.*, *W.*

Graphis scripta Ach., *W.*

Enterographa crassa Fee, *F.*

Coriscium viride Zahlbr., *F.*

THE LUDLOW FORAY

20–25 September 1937

By C. G. C. CHESTERS

The forty-first Autumn Foray and Annual General Meeting was held at Ludlow during the week of 20–25 September. Headquarters were established at the Angel Hotel, where an excellent display room was placed at the disposal of the Society.

Members who had arrived during the week-end explored on Monday the woods lying near the town. The first official excursion took place on Tuesday when a large party of members left headquarters by car for Haye Park. Here both *Entomophthora sphaerosperma*, on Hemiptera, and *E. dipterigena*, on flies, were collected. This oak wood proved to be rather dry and many members continued along the road through the wood to the Haye Park Woods which, lying in a valley, were much more fruitful of fungi. Several excellent specimens of *Fistulina hepatica* were observed soon after entering the woods. *Femsjonia luteo-alba* was very plentiful and the mossy banks by the sides of the "drives" yielded some fine specimens of *Spicaria* (*Isaria*) *farinosa*. The floor of the valley was particularly rich in fallen timber and many resupinate Basidiomycetes were collected as well as some very fine specimens of *Anthostoma dryophilum*. One oak branch exhibited normal stromata at one end, and at the other, stromata so deeply immersed in the partially decayed wood, that they could not be recognzied as belonging to this species, except upon microscopic examination. The Haye Park Woods must be considered as an outstanding station for this fungus, as, towards the end of the day it was encountered on more than one occasion both on fallen and attached branches. Some very large specimens of *Daedalea quercina* were taken near the top of the wood. Many of the oak trees were severely infected by *Colpoma quercina* which was, on many trees, responsible for a dieback of almost 20 per cent of the branches.

Most of the party walked to the Whitcliffe Woods on the Wednesday. These are mixed deciduous woods planted along the aqueduct supplying Birmingham. Shortly after entering the woods, *Nummularia lutea* was obtained on decayed oak showing the characteristic yellow stain, and *Diatrype Stigma* with its *Naemospora* stage was found on *Quercus*. Mr Pearson collected *Flammula limulata*. A magnificent specimen of *Polyporus giganteus* was found in the lower part of the wood. In the birch wood on the upper side of the road, *Massaria*

Argus was collected on freshly cut *Betula*. This Pyrenomycete is one of the original group of species recorded by the "Mycological Fathers" which has, I think, not been recorded in our lists—at least in recent years. *Thecopsora Vacciniorum* was collected on *Vaccinium Myrtilis*. *Phyllactinia corylea* was extremely common, and, during the late afternoon Mr Ramsbottom conducted a party to a spot where this species, *Erysiphe tortilis* and *Uncinula Aceris* were especially abundant. Certain University Departments "laid in" a considerable stock of material as a result of this outing.

On Thursday, Boyne Park was visited, and many members, recalling a Spring Foray to this area, looked forward to high class collecting. The very hot weather was rather against this, but the phytopathologists spent a profitable time in the kitchen and flower gardens where *Puccinia Pruni-spinosae* and *P. mirabilissima* were collected. *Melampsorella Symphyti* was found in its former place but teleutosori were searched for in vain.

Marssonina Delastrei on *Lychnis dioica* was found by Mr Moore, who writes that this is only the third foray on which it has been discovered. *Spicaria farinosa* and *Entomophthora dipterigena* were plentiful on certain on the moss-covered banks. Very few of the larger fungi were taken and none of these was of particular interest. Everyone welcomed tea at the Boyne Arms at 4.30 p.m., at the end of a pleasant but not particularly productive excursion.

Kinlet Park was visited on Friday and the morning was spent in Birchen Park, which is a mixed woodland. Some fine specimens of *Hypoxylon Howieanum* were collected on *Corylus* but little else of interest was observed. The afternoon was spent along the stream draining High Wood. Here, some good specimens of *Trametes mollis* were obtained.

Many of the members left for home on Saturday morning, and it was a small party that travelled to Downton Castle for the final excursion. This area is well worth a more prolonged visit. The woods, which are mainly deciduous, are situated in the valley of the Teme where it passes through a limestone gorge. The road along the river passes through what is alleged to be a Roman cave, but this, like the Roman baths on the opposite bank, was built by one of the former owners of the Castle. Members who collected the larger fungi commented on the richness of the area. *Cryptosporella hypodermia* was collected on elm by the river banks soon after passing the cave. This species does not figure in recent foray lists and, in my experience it is only found commonly on elm in woods—roadside trees are seldom infected—and then only on the ends of living branches. Discovery and identification in the field are difficult but if material suspected to bear the fungus is retained in a vasculum or a box for a day, the characteristic white exudate of spores clinging to the ostioles of the

perithecia may appear, and render easy the location of the small stromata. In an ash grove by the river, *Hypoxylon argillaceum* was obtained with gratifying frequency from its characteristic situation at the base of dead twigs some distance above ground level. Here also, fine specimens of *Cyathus striatus* were collected on fallen timber.

During the week, several evening meetings were held. The Council Meeting on Monday evening was followed by the Annual General Meeting on Tuesday, 21 September, when the Officers for 1938 were elected. Miss K. Sampson was chosen as President for 1938 supported by Mr Cartwright and Dr Morgan as Vice-Presidents. The other officers were re-elected. Miss D. M. Cayley, Mr W. C. Moore and Dr Morgan retired from the Council in accordance with the rules and Miss E. F. Noel, Dr G. R. Bisby and Mr W. P. Findlay were elected in their place. Dr S. Dickinson was appointed delegate to the British Association at Cambridge.

Dr G. C. Ainsworth read his report of the British Association Meeting at Nottingham. This was adopted, the President expressing the thanks of the Society to Dr Ainsworth. After discussing a proposal by the President, Mr Cartwright, that Rule 6 should be modified in such a way that from January 1937 the retiring President should become a Vice-President for two years, the meeting requested the Secretary to give notice that it is proposed to alter Rule 6 to read as follows

> The government of the Society shall be vested in a Council, which shall consist of the President and other Officers for the time being, together with *nine* other members, three of whom shall be elected at the Annual General Meeting to replace three retiring members, who shall not be eligible for immediate re-election. *Ex-Presidents who have served their year of office prior to 31st December,* 1936, *are ex-officio members of the Council. From* 1937 *the retiring President shall become a Vice-President for a period of two years.*

The proposed alteration will come up for discussion at the Annual General Meeting in 1938. It was decided by a majority vote that the Autumn Foray and Annual General Meeting in 1938 should be held in Scotland.

A severe cold prevented Mr Cartwright from delivering his Presidential Address on Wednesday evening on "The Relation between Field and Laboratory Work in Mycology". The address was read by Mr Ramsbottom, who expressed the deep sympathy of the meeting with our president and wished him, on behalf of everyone present, a speedy recovery.

At the close of the meeting, very hearty votes of thanks were passed to all the landowners whose estates had been visited.

The records from which the following list of species was compiled were supplied by all members present. The secretary is particularly indebted to Miss Sampson, Mr Ramsbottom, Mr Pearson, Mr Petch, Mr Mason and Dr Ainsworth for detailed lists of species they collected.

List of species gathered during the Foray

L. = Ludlow; *H.* = Haye Park; *W.* = Whitcliffe Wood; *Hc.* = Hopton Changeford; *B.* = Boyne Park; *K.* = Kinlet; *D.* = Downton Castle.

HYMENOMYCETES

Pluteus cervinus (Schaeff.) Fr., *H.*, *B.*, *K.*, *D.*, nanus (Pers.) Fr., *H.*, *D.*, var. lutescens Fr., *B.*

Lepiota rhacodes (Vitt.) Fr., *W.*, acutesquamosa (Weinm.) Fr., *D.*, cristata (A. & S.) Fr., *H.*, cepaestipes (Sow.) Fr., *H.*, var. cretacea (Bull.) Fr., *B.*, amianthina (Scop.) Fr., *H.*, seminuda (Lasch.) Fr., *D.*

Psaliota campestris (Linn.) Fr., *D.*, *W.*, sylvicola (Vitt.) Fr., *H.*, sylvatica (Schaeff.) Fr., *W.*

Amanitopsis fulva (Schaeff.) W. G. Sm., *B.*

Amanita mappa (Batsch) Fr., *H.*, *W.*, muscaria (Linn.) Fr., *K.*, rubescens (Pers.) Fr., *B.*, *H.*

Armillaria mellea (Vahl) Fr., *H.*, *K.*, *W.*

Pholiota erebia Fr., *B.*, togularis (Bull.) Fr., *H.*, *B.*, *D.*, squarrosa (Müll.) Fr., *H.*, *W.*, *D.*, spectabilis Fr., *W.*, *B.*, marginata (Batsch) Fr.

Stropharia aeruginosa (Curt.) Fr., *B.*, *W.*, *K.*, albocyanea (Desm.) Fr., *H.*, squamosa (Pers.) Fr., *W.*, var. aurantiaca Cke., *H.*, semiglobata (Batsch) Fr., *H.*, *W.*, *B.*, *K.*, *D.*

Cortinarius (Phlegmacium) purpurascens Fr., *D.*, (Myxacium) elatior Fr., *H.*, (Dermocybe) myrtillinus Fr., *W.*, (Telamonia) hinnuleus (Sow.) Fr., *B.*, *D.*, gentilis Fr., *Hc.*, brunneus (Pers.) Fr., *H.*, *W.*, (Hydrocybe) subferrugineus (Batsch) Fr., *Hc.*, *B.*, castaneus (Bull.) Fr., *Hc.*, *B.*

Inocybe geophylla (Sow.) Fr., *H.*, *W.*, *D.*, var. lilacina Fr., *H.*, descissa Fr., *K.*, rhodiola Bres., *B.*

Asterosporina praetervisa (Quél.) Schroet., *B.*

Tricholoma resplendens Fr., *H.*, *W.*, *B.*, spermaticum (Paul.) Fr., *W.*, *Hc.*, *B.*, fulvum (DC.) Fr., *W.*, *B.*, rutilans (Schaeff.) Fr., *H.*, *K.*, *D.*, psammopum Kalchbr., *H.*, *B.*, album (Schaeff.) Fr., *D.*, nudum (Bull.) Fr., *D.*, cinerascens (Bull. non Fr.) Quél., *W.*, *D.*, grammopodium (Bull.) Fr., *H.*, *D.*, melaleucum (Pers.) Fr., *H.*, *W.*, *D.*

Entoloma porphyrophaeum Fr., *B.*, sericeum (Bull.) Fr., *W.*, *B.*, *D.*

Hebeloma glutinosum (Lindgr.) Fr., *W.*, mesophaeum Fr., *K.*, crustuliniforme (Bull.) Fr., *H.*, *K.*, saccharіolens Quél., *H.*, *W.*

Hypholoma sublateritium (Schaeff.) Fr., *D.*, fasciculare (Huds.) Fr., *K.*, *D.*, pyrotrichum (Holmsk.) Fr., *H.*, velutinum (Pers.) Fr., *H.*, appendiculatum (Bull.) Fr., *W.*, hydrophilum (Bull.) Fr., *H.*, *W.*, *K.*, *D.*

Clitocybe clavipes (Pers.) Fr., *H.*, *K.*, aurantiaca (Wulf.) Studer, *H.*, *W.*, *B.*, *K.*, *D.*, rivulosa (Pers.) Fr., *B.*, infundibuliformis (Schaeff.) Fr., *W.*, *Hc.*, *D.*, inversa (Scop.) Fr., *B.*, flaccida (Sow.) Fr., *H.*, *D.*

Laccaria laccata (Scop.) B. & Br., *H.*, *W.*, *B.*, *D.*

Hygrophorus pratensis (Pers.) Fr., *D.*

Clitopilus prunulus (Scop.) Fr., *H.*, *W.*, *Hc.*

Flammula gummosa (Lasch) Fr., *D.*, sapinea Fr., *H.*, *B.*, *D.*, ochrochlora Fr., *H.*, limulata Fr., *K.*

Collybia radicata (Relh.) Berk., *H.*, *K.*, fusipes (Bull.) Berk., *H.*, *W.*, lancipes Fr., *H.*, maculata (A. & S.) Fr., *W.*, *B.*, tuberosa (Bull.) Fr., *B.*, rancida Fr., *D.*

Leptonia euchroa (Pers.) Fr., *H.*

Naucoria Cucumis (Pers.) Fr., *H.*, centunculus Fr., *D.*, melinoides Fr., *W.*, striaepes Cke., *D.*, escharoides Fr., *H.*, *B.*, *D.*, submelinoides Kühner var. alnetorum Maire, *H.*

Psilocybe subericaea Fr., *W.*, semilanceata Fr., *H.*, *W.*, *B.*, *K.*, spadicea Fr., *W.*, foenisecii (Pers.) Fr., *B.*, *D.*

Paneolus campanulatus (Linn.) Fr., *B.*, papilionaceus (Bull.) Fr., *K.*, *B.*

Mycena rubro-marginata Fr., *W.*, *B.*, pura (Pers.) Fr., *W.*, *D.*, lineata (Bull.) Fr., *H.*, flavo-alba Fr., *D.*, gypsea Fr., *H.*, galericulata (Scop.) Fr., *H.*, *B.*, *K.*, *D.*, polygramma (Bull.) Fr., *W.*, *B.*, inclinata Fr., *H.*, *W.*, *D.*, ammoniaca Fr., *H.*, *D.*, metata Fr., *H.*, *K.*, *B.*, Iris Berk., *W.*, *B.*, vitilis Fr., *B.*, sanguinolenta (A. & S.) Fr., *H.*, *W.*, *B.*, *K.*, galopus (Pers.) Fr., *H.*, *W.*, *B.*, *D.*, var. nigra Fl. Dan., *H.*, *W.*, *B.*, epipterygia (Scop.) Fr., *W.*, clavicularis Fr., *D.*, hiemalis (Osbeck) Fr., *D.*

Nolanea proletaria Fr , *W.*, *D.*, strigosissima Rea, *H.*, papillata Brcs., *K.*

Galera tenera (Schaeff.) Fr., *H.*, *W.*, *B.*, *D.*, rubiginosa (Pers.) Fr., *H.*, hypnorum (Schrank) Fr., *H.*, *W.*

Psathyra fibrillosa (Pers.) Fr., *W.*, *B.*, gossypina (Bull.) Fr., *K.*

Psathyrella subatrata (Batsch) Fr., *W.*, *Hc.*, *B.*, gracilis Fr., *H.*, *W.*, *B.*, prona Fr., *Hc.*, atomata Fr., *H.*, disseminata (Pers.) Fr., *H.*

Tubaria furfuracea (Pers.) W. G. Sm., *H.*, *W.*, *B.*, *D.*

Pleurotus ostreatus (Jacq.) Fr., *D.*

Schizophyllum commune Fr., *H.*

Claudopus variabilis (Pers.) W. G. Sm., *H.*

Crepidotus mollis (Schaeff.) Fr., *H.*, *D.*

Russula delica Fr., *W.*, chloroides (Krombh.) Bres. *B.*, nigricans (Bull.) Fr., *W.*, *B.*, *D.*, lepida Fr., *H.*, *W.*, azurea Bres., *B.*, cyanoxantha (Schaeff.) Fr., *B.*, *K.*, foetens (Pers.) Fr., *Hc.*, *B.*, pectinata (Bull.) Fr., *B.*, ochroleuca (Pers.) Fr., *W.*, *B.*, fellea Fr., *B.*, fragilis (Pers.) Fr., *H.*, emetica (Schaeff.) Fr., *H.*, *W.*, atropurpurea (Krombh.) Maire, *H.*, *W.*, *Hc.*, *B.*, xerampelina (Schaeff.) Fr., *K.*, vesca Fr., *H.*, *W.*, *D.*, caerulea Cke., *B.*, lutea (Huds.) Fr., *H.*, Velenovskyi Metzer & Zvara, *W.*, pseudointegra Arn. & Gor., *Hc.*, *K.*, *W.*, versicolor J. Schaeffer, *K.*

Lactarius torminosus (Schaeff.) Fr., *B.*, turpis (Weinm.) Fr., *H.*, *B.*, blennius var. viridis (Schrad.) Quél., *B.*, pyrogalus (Bull.) Fr., *W.*, vellereus Fr., *K.*, *B.*, *D.*, pallidus (Pers.) Fr., *D.*, quietus Fr., *H.*, *W.*, spinosulus Quél., *D.*, serifluus (DC.) Fr., *H.*, *W.*, *D.*, mitissimus Fr., *K.*, tabidus Fr., *H.*

Coprinus comatus (Fl. Dan.) Fr., *W.*, atramentarius (Bull.) Fr., *H.*, *K.*, cinereus (Schaeff.) Cke., *B.*, micaceus (Bull.) Fr., *H.*, *B.*, *D.*, lagopus Fr., *H.*, *W.*, *B.*, *K.*, ephemerus (Bull.) Fr., *B.*, plicatilis (Curt.) Fr., *H.*, *W.*, *B.*, *D.*

Marasmius peronatus (Bolt.) Fr., *H.*, *B.*, *K.*, erythropus (Pers.) Fr., *H.*, hariolorum (DC.) Quél., *H.*, *B.*, *K.*, *D.*, dryophilus (Bull.) Karst., *H.*, *W.*, *B.*, *D.*, var. aquosus (Bull.) Rea, *W.*, cohaerens (A. & S.) Cke., *D.*

Androsacens rotula (Scop.) Pat., *H.*, *K.*, androsaceus (Linn.) Pat., *H.*, Hudsonii (Pers.) Pat., *W.*

Panus stipticus (Bull.) Fr., *K.*

Nyctalis parasitica (Bull.) Fr., *W.*

Cantharellus cibarius Fr., *H.*, *W.*, *K.*, *D.*

Paxillus involutus (Batsch) Fr., *H.*, *W.*, *K.*

Strobilomyces strobilaceus (Scop.) Berk. *D.*

Boletus elegans (Schum.) Fr., *H.*, *W.*, viscidus (Linn.) Fr., *W.*, *B.*, chrysenteron (Bull.) Fr., *B.*, scaber (Bull.) Fr., *H.*

Polyporus brumalis (Pers.) Fr., *H.*, picipes Fr., *D.*, squamosus (Huds.) Fr., *H.*, giganteus (Pers.) Fr., *H.*, *W.*, betulinus (Bull.) Fr., *H.*, *W.*, *B.*, *K.*, dryadeus (Pers.) Fr., *D.*, adustus (Willd.) Fr., *K.*, *D.*, caesius (Schrad.) Fr., *H.*, *D.*, stipticus (Pers.) Fr., *K.*

Fomes annosus Fr., *H.*, *W.*

Ganoderma applanatum (Pers.) Pat., *H.*, *W.*, *D.*

Poria eupora Karst., *H.*, sanguinolenta (A. & S.) Fr., *K.*

Polystictus versicolor (Linn.) Fr., *H.*, *K.*, *W.*, *D.*, abietinus (Dicks.) Fr., *W.*

Irpex obliquus (Schrad.) Fr., *H.*, *W.*, *K.*

Trametes rubescens (A. & S.) Fr., *H.*, mollis (Sommerf.) Fr., *B.*, serpens Fr., *D.*

Daedalea biennis (Bull.) Quél., *H.*, quercina (Linn.) Fr., *H.*, *K.*

Merulius tremellosus (Schrad.) Fr., *K.*, rufus (Pers.) Fr., *K.*, lacrymans (Wulf.) Fr., *B.*

Coniophora arida Fr., *K.*
Fistulina hepatica (Huds.) Fr., *H.*, *W.*, *D.*
Hydnum repandum (Linn.) Fr., *H.*, *D.*
Grandinea farinacea (Pers.) Bourd. & Galz., *H.*
Odontia barba-Jovis (With.) Fr., *W.*, *B.*
Hypochnus fuscus (Pers.) Fr., *H.*, fumosus Fr., *H.*, *K.*
Stereum spadiceum Fr., *H.*, hirsutum (Willd.) Fr., *H.*, *W.*, *B.*, purpureum (Pers.) Fr., *B.*, bicolor (Pers.) Fr., *H.*
Hymenochaete rubiginosum (Dicks.) Lév., *B.*, *D.*
Corticium laeve (Pers.) Quél., *H.*, comedens (Nees) Fr., *H.*, *K.*, (Gloeocystidium) roseo-cremeum Bres., *K.*
Peniophora sanguinea (Fr.) Bres., *H.*, velutina (DC.) Cke., *K.*, setigera (Fr.) Bres., *H.*, *W.*, hydnoides Cke. & Massee, *H.*, quercina (Pers.) Cke., *H.*, *K.*
Solenia anomala (Pers.) Fr., *H.*
Clavaria cristata (Holmsk.) Fr., *K.*, *W.*, *B.*, cinerea (Bull.) Fr., *D.*, rugosa (Bull.) Fr., *D.*, stricta (Pers.) Fr., *W.*, *D.*, pistillaris (Linn.) Fr., *H.*, *D.*, fistulosa (Holmsk.) Fr., *H.*, *B.*
Pistillaria quisquiliaris Fr., *H.*, *B.*
Auricularia auricula-Judae (Linn.) Schroet., *H.*, *W.*
Tremella mesenterica (Retz.) Fr., *H.*
Exidia glandulosa (Bull.) Fr., *H.*
Sebecina fugacissima Bourd. & Galz., *B.*
Tulasnella incarnata Juel, *H.*
Femsjonia luteo-alba Fr., *H.*, *K.*
Calocera viscosa (Pers.) Fr., *H.*, *B.*, *K.*, cornea (Batsch) Fr., *W.*, *D.*

GASTEROMYCETES

Phallus impudicus (Linn.) Pers., *H.*, *D.*
Lycoperdon depressum Bon., *W.*, *D.*, perlatum Pers., *W.*, *D.*, pyriforme (Schaeff.) Pers., *H.*, *W.*, *K.*
Bovista nigrescens Pers., *B.*
Crucibulum vulgare Tul., *H.*
Scleroderma aurantiacum Pers., *K.*, verrucosum (Vaill.) Pers., *H.*
Cyathus striatus (Huds.) Pers., *D.*

UREDINALES

Uromyces Fabae (Pers.) de Bary, *W.*, *B.*, *K.*, Rumicis (Schum.) Wint., *W.*, Dactylidis Otth., *H.*, *K.*, Poae Rabenh., *H.*, *K.*
Puccinia Violae (Schum.) DC., *H.*, *W.*, Lychnidiarum Link., *H.*, *B.*, mirabilissima Peck, *B.*, Pruni-spinosae Pers., *B.*, Circaeae Pers., *H.*, *K.*, *W.*, Saniculae Grev., *H.*, *W.*, punctata Link, *W.*, obtegens (Link) Tul., *H.*, *W.*, *B.*, Glechomatis DC., *K.*, Menthae Pers., *H.*, obscura Schroet., *W.*, graminis Pers., *H.*, *W.*, *K.*, coronata Corda, *H.*, *K.*, glumarum (Sch.) Erikss. & Henn., *H.*, dispersa Erikss. & Henn., *W.*, *K.*, holcina Erikss., *H.*, Baryi (B. & Br.) Wint., *H.*
Triphragmium Ulmariae (Schum.) Link, *H.*
Phragmidium Potentillae (Pers.) Wint., *W.*, Fragariastri (DC.) Schroet., *W.*, Rubi (Pers.) Wint., violaceum (Schultz) Wint., *W.*, *K.*
Coleosporium Rhinanthacearum Lév., *W.*, Senecionis (Pers.) Fr., *W.*, Tussilaginis (Pers.) Kleb., *W.*, *K.*
Cronartium rubicolum Dietr., *B.*
Pucciniastrum Circaeae (Schum.) Schroet., *W.*, *K.*, Agrimoniae (DC.) Tranzschel, *K.*, pustulatum Diet., *W.*, *K.*, (Thecopsora) Vacciniorum (Link) Diet., *H.*, *W.*
Melampsora Euphorbiae Cast., *W.*
Melampsoridium betulinum (Pers.) Kleb., *H.*, *W.*, *B.*
Melampsorella Symphyti (DC.) Bubák, *B.*
Milesina Blechni Sydow, *W.*, Scolopendrii Schroet., *W.*

USTILAGINALES

Ustilago striiformis (Westen.) Niess., *K.*
Tilletia rauwenhoffi Fisch. de Wald., *B.*
Urocystis Anemones (Pers.) Schroet., *K.*
Sphacelotheca Hydropiperidis (Schum.) de Bary, *K.*

PYRENOMYCETES

Sphaerotheca pannosa (Wallr.) Lév., *W.*, Humuli (DC.) Burr., *B.*
Podosphaera Oxyacanthae (DC.) de Bary, *W.*, leucotricha (Ell. & Everh.) Salmon, *B.*
Erysiphe graminis DC., *W.*, *K.*, Polygoni DC., *W.*, *B.*, *D.*, tortilis (Wallr.) Fr. (=Trichocladia tortilis (Wallr.) Neger), *W.*
Microsphaera Grossulariae Lév., *B.*, Alni. (DC.) Winter, *W.*
Uncinula Aceris (DC.) Sacc., *W.*, *B.*, *K.*
Phyllactinia corylea (DC.) Karst., *W.*
Diplocarpon Rosae Wolf (and as Actinonema Rosae Fr., stage) *H.*, *W.*, *K.*
Trichosphaeria minima (Fuckel & Nits.) Wint., *K.*
Leptospora spermoides (Hoff.) Fuckel, *K.*, ovina (Pers.) Fuckel, *D.*
Chaetosphaeria phaeostroma Fuckel, *K.*
Zignoella Pulviscula (Curr.) Sacc., *B.*
Melanomma Pulvis-pyrius (Pers.) Fuckel, on *Betula* and *Quercus H.*, on *Betula*, *K.*, fuscidulum Sacc., on *Fagus*, *B.*
Stigmatea Robertiani Fr., *W.*
Mycosphaerella brassicicola (Duby) Lindau, *B.*, Fragariae (Tul.) Lindau, *B.*, punctiformis (Pers.) Schröter, *W.*
Venturia Rumicis (Desm.) Wint., *B.*, pirina Aderh., *K.*, inaequalis (Cke.) Aderh., *B.*, *K.*
Didymella applanata (Niessl) Sacc., *B.*
Leptosphaeria acuta (Moug.) Karst., on *Urtica*, *K.*
Massaria Argus (B. & Br.) Tul., on freshly cut *Betula*, *W.*
Diaporthe eres Nits., on *Ulmus*, *D.*, (? eres) on *Hedera*, *D.*, leiphemia (Fr.) Sacc., *H.*
Melanconis stilbostoma (Fr.) Tul., on *Betula*, *H.*, *K.*
Pseudovalsa lanciformis (Fr.) Tul., on *Betula*, *D.*
Cryptosporella hypodermia (Fr.) Sacc., on *Ulmus*, *D.*
Sillia ferruginea (Pers.) Karst., on *Corylus*, *W.*
Peroneutypa heteracantha Sacc., on *Sambucus*, *D.*
Eutypa flavovirens (Fr.) Tul., on *Acer*, *K.*
Cryptosphaeria eunomia (Fr.) Fuckel, on *Fraxinus*, *K.*, *D.*
Quaternaria quaternata (Pers.) Schroet., *B.*, dissepta (Fr.) Tul., *D.*
Diatrype Stigma (Hoffm.) Fr., on *Fraxinus*, *D.*, on *Quercus*, *W.*, on *Sambucus*, *D.*
Diatrypella quercina (Pers.) Nitschke, on *Quercus*, *W.*, *B.*, *K.*, favacea (Fr.) Ces. & de Not., on *Betula*, *H.*, *K.*, on *Alnus* (=D. Tocciaeana de Not.), *D.*, on *Corylus* (=D. verruciformis (Ehrh.) Nitschke), *W.*
Eutypella stellulata (Fr.) Sacc., on *Ulmus*, *D.*
Anthostoma dryophilum (Curr.) Sacc., on *Quercus*, *H.*
Nummularia lutea Nits., on *Quercus*, *W.*
Ustulina vulgaris Tul., *K.*
Hypoxylon multiforme Fr., on *Betula*, *H.*, *W.*, *K.*, serpens (Pers.) Fr., *H.*, semi-immersum Nits., on *Quercus*, *W.*, rubiginosum (Pers.) Fr., on *Fraxinus*, *D.*, coccineum Hull., on *Fagus*, *W.*, Howieanum Pk., on *Corylus*, *W.*, *B.*, fuscum (Pers.) Fr., on *Corylus*, *W.*, *K.*, *D.*, on *Alnus*, *D.*, argillaceum (Pers.) Berk., on *Fraxinus*, *D.*
Xylaria carpophila (Pers.) Fr., *H.*, Hypoxylon (Linn.) Grev., *W.*, *D.*, polymorpha (Pers.) Grev., *H.*
Hectria cinnabarina (Tode) Fr., *B.*, *K.*, coccinea (Pers.) Fr., on *Ulmus*, *K.*, punicea (K. & S.) Fr., on *Fagus*, *H.*, mammoidea Phill. & Plowr., on *Ulex*, *B.*

Dialonectria sanguinea (Bolt.) Cke., on *Diatrype Stigma*, *K.*, Peziza (Tode) Cke., *B.*, galligena (Bres.) Petch, on *Pyrus Malus*, *B.*
Hypocrea pulvinata Fuckel, on *Polyporus betulinus*, *H.*, *B.*
Cordyceps militaris (Linn.) Link, *W.*, *D.*
Claviceps purpurea (Fr.) Tul., on *Holcus mollis*, *H.*, *W.*, *B.*
Phyllachora graminis (Pers.) Fuckel, *K.*
Rhopographus filicinus (Fr.) Nitschke, *W.*, *B.*

DISCOMYCETES

Pustularia catinus (Holmsk.) Fuckel, *H.*
Peziza aurantia Pers., *H.*
Coprobia granulata (Bull.) Boud., *B.*
Ascobolus stercorarius (Bull.) Schroet., *B.*
Taphrina Tosquinetti (West.) P. Magn., *K.*, turgida Sadeb., *B.*, Betulae (Fuckel) Johanson, *B.*
Leotia lubrica (Scop.) Pers., *D.*
Coryne sarcoides (Jacq.) Tul., *H.*, *B.*, *D.*
Bulgaria inquinans (Pers.) Fr., *H.*
Corynella glabro-virens Boud., *B.*
Orbilia leucostigma Fr., *B.*, xanthostigma Fr., *W.*, *K.*, *D.*
Phialea firma (Pers.) Gill., *H.*, *B.*
Helotium citrinum (Hedwig) Fr., *H.*
Dasyscypha virginea (Batsch) Fuckel, *H.*
Trichoscypha calycina (Schum.) Boud., *W.*
Mollisia cinerea (Batsch) Karst., *H.*, *D.*
Tympanis conspersa Fr., *K.*
Propolis faginea (Schrad.) Karst., *D.*
Pseudopeziza Trifolii (Biv.-Bern.) Fuckel, *H.*, *K.*
Stegia Ilicis Fr., *W.*
Colpoma quercinum (Pers.) Wallr., *H.*, *K.*
Rhytisma acerinum (Pers.) Fr., *W.*, *B.*, *K.*

HYSTERIALES

Hysterium angustatum (A. & S.) Sacc., on *Sambucus*, *D.*

PHYCOMYCETES

Plasmopara nivea (Unger) Schroet., *L.*
Bremia Lactucae Regel, *B.*, *W.*
Peronospora effusa (Grev.) Rabenh., *H.*, Urticae (Lib.) de Bary, *B.*, parasitica (Pers.) Tul., *B.*
Thamnidium elegans Link, *W.*
Pilobolus crystallinus (Wiggers) Tode, *B.*
Empusa Muscae Cohn, *B.*
Entomophthora sphaerosperma Fres., *H.*, americana Thaxt., *H.*, *B.*, echinospora Thaxt., *B.*, dipterigena Thax., H.
Protomyces macrosporus Ung., *K.*

DEUTEROMYCETES

Macrophoma Mirbelii B. & V., *B.*, Fraxini Delacr., *W.*
Septoria Petroselini Desm., *B.*, Rubi Westd., *W.*
Marssonina Delastrei Magn., *B.*
Gliocladium album (Preuss) Petch, on *Physarum nutans*, *W.*
Sepedonium chrysospermum (Bull.) Fr., *H.*, *B.*, *W.*
Ovularia obliqua (Cke.) Oud., *W.*, *B.*, deusta (Fuck.) Sacc., *B.*, duplex Sacc., *W.*
Cylindrodendrum album Bon., on *Betula* catkins, *H.*

Botrytis cinerea Pers., *B.*
Spicaria (Isaria) farinosa (Holms.) Petch, *H.*, *W.*, *B.*, *K.*
Hymenostilbe muscaria Petch, on *flies*, *W.*, *B.*, arachnophila (Ditm.) Petch, on *spiders*, *W.*, *K.*
Mastigosporium album Riess, *K.*
Ramularia Urticae Ces., *W.*, pratensis Sacc., *B.*, beticola Fautr. & Lamb., *B.*, acris Lindr., *W.*, Gei (Eliass.) Lindr., *W.*, lactea (Desm.) Sacc., *B.*, montana Speg., *W.*, Primulae v. Thüm., *W.*, Ajugae (Niessl) Sacc., calcea (Desm.) Ces., *B.*, Stachydis (Passer.) Massal., *W.*, Scrophulariae Fautr. & Roum., *B.*
Hadrotrichum virescens Sacc. & Roum., *H.*
Fusicladium pirinum var. pyracanthae v. Thüm., *B.*
Scolecotrichum graminis Fuckel, *H.*
Cladosporium herbarum (Pers.) Link, on *flies* with *Empusa Muscae*, *B.*
Polythrincium Trifolii Kunze, *W.*
Cercospora Mercurialis Passer., *B.*
Volutella Buxi (Corda) Berk., *B.*

MYCETOZOA FOUND DURING THE FORAY OF THE BRITISH MYCOLOGICAL SOCIETY AT LUDLOW

20–25 September 1937

By M. W. REA

The Mycetozoa obtained during the foray were disappointing both in number and in interest. Thirteen of the more common species and one sub-species were observed. The weather had been very dry during August and this partly accounts for the scanty finds. The best hunting ground was hazel scrub in a damp part of Whitcliffe Wood. *Physarum nutans* turned up frequently as well as *Trichia persimilis* and *T. decipiens*. Conditions were very dry at Boyne Park. In the woodyard, *Ceratiomyxa fruticulosa*, *Physarum nutans*, and its sub-species *leucopheum*, *Arcyria denudata* and *Trichia decipiens* were found. Better results were hoped from the mixed woods of the Kinlet district including oak and pine. There, *Physarum nutans* was collected several times, and also *Tubifera ferruginosa*, *Arcyria denudata* and *Trichia varia*.

In the following list *H.*, *W.*, *B.*, and *K.*, stand for Haye Park Woods, Whitcliffe Woods, Boyne Park and Kinlet district respectively.

Ceratiomyxa fruticulosa (Mueller) Macbr., *W.*, *B.*
Physarum nutans Pers. and var. leucopheum Lister, *H.*, *W.*, *K.*, *B.*
Fuligo septica (L.) Gmel., *H.*
Comatricha nigra (Pers.) Schroeter, *W.*
Tubifera ferruginosa Gmel., *K.*
Lycogola epidendrum (L.) Fries, *H.*, *W.*, *B.*
Trichia affinis de Bary, *H.*
,, decipiens (Pers.) Macbr., *W.*, *B.*
,, persimilis Karsten, *W.*
,, varia Pers., *K.*
Arcyria cinerea (Bull.) Pers., *B.*
,, denudata (L.) Wettst., *H.*, *B.*, *K.*
,, incarnata Pers., *H.*
Dictydium cancellatum Macbr., *K.*

THE PHYTOPATHOLOGICAL EXCURSION

By G. C. AINSWORTH

The Fourteenth Phytopathological Excursion was held at the South-Eastern Agricultural College, Wye, Kent, by kind permission of the Principal, R. M. Wilson, Esq., B.Sc. (Agric.), on Saturday, 3 July 1937.

In the morning, after Prof. Salmon and Dr Ware had briefly outlined the scope of the pathological work at the College, Dr Goodwin discussed his use of the *Aspergillus* method for estimating the manurial requirements of agricultural soils and Mr C. Davies gave an interesting demonstration of different types of spray nozzles and explained the methods used for examining sprays and spray deposits. The commercial preparation of mushroom spawn was studied and then the laboratories were inspected where exhibits of mushroom diseases and other phytopathological items were displayed. In the afternoon, a visit was made to the hop trial grounds and to the fruit plantations. Tea followed, and the proceedings closed with a vote of thanks to the College authorities for the very generous hospitality extended to the visitors.

PRESIDENTIAL ADDRESS

THE RELATION BETWEEN FIELD AND LABORATORY WORK IN MYCOLOGY

By K. St G. CARTWRIGHT

Mycology in its early days was mainly concerned with collecting and descriptive work based on external morphological characters; thus we find that most of the early work was carried out by amateurs as a hobby.

At first there was a tendency to multiply species, but as the wide variation in external characters within a single species which earlier would have been considered sufficient to justify the making of a new species began to be recognized, this tendency was checked. The use of a hand lens was soon brought into requisition and later the microscope. With the improvement of objectives, more and more attention began to be paid to microscopic details, at first merely as illustrating the powers of the new instrument by microscopists.

Thus the tendency grew amongst certain workers to discount the value of macroscopic characters, and undue stress was perhaps laid on microscopic ones. Gradually, descriptive mycology as practised by the field naturalist came to be looked down upon as a harmless hobby, and the study of fungi tended to pass out of the hands of the amateur old-time naturalist who lacked the somewhat expensive equipment thought to be necessary.

The fact that few of the fleshy fungi could be preserved, as could flowering plants, tended also to deter many of the younger naturalists from taking them up, as records of these species could be kept only by making coloured drawings, and this demanded both time and a certain amount of artistic ability, and, moreover, there was little appeal to the collector's instinct.

Improvements in the microscope led to a study of the micro-fungi, and the economic importance of many of these being realized, mycologists began to turn rather to the effects and causes of disease on the host plant and to discount the older descriptive work.

In everything a few pioneers lead the way and the less gifted masses tend to follow like sheep and to neglect other aspects of the subject. Fashion in science, as in attire, is all-powerful.

Thus mycology became more and more a matter of laboratory study divorced from field work.

Again, the importance to the community of controlling plant diseases caused by fungi had the effect of creating a demand for paid research workers, and plant pathology gave openings for many young men who had no real interest except that they had to earn a living, but little encouragement was given to systematic work as it appeared to have little direct economic value.

So a race of workers arose possessing a very rudimentary knowledge of systematics, and the tendency was to look down on those who took it up as a hobby. The unhealthy situation thus arose of the title of amateur becoming one of scorn, and their work was discounted.

This barrier between the two tended to become greater as more and more stress was laid on the laboratory type of physiological work, much of which was entirely divorced from field work.

I have actually heard some misguided young phytopathologists pride themselves on their ignorance about systematic mycology. I am happy to say that as far as this Society is concerned this attitude has never been adopted, and these field meetings are to me, and I think to most of us, very helpful; I, personally, have picked up most of what little knowledge I possess in systematic mycology from fellow-members.

Field work is of particular interest to me since I am by nature primarily a naturalist, and I never come back from a day in the field without obtaining some inspiration. I am convinced that the solution to most biological problems lies in close observation in the field, followed wherever necessary by confirmation in the laboratory. Much time is saved by this method of approach rather than the reverse, and many absurd conclusions based on the behaviour of plants under so-called controlled conditions, which may mean very abnormal ones, would be avoided if the workers had made full observations in the field before beginning laboratory work. Until you know your plant in the field, whether it is a fungus or a green plant, there is little use studying its behaviour in the laboratory.

Perhaps these preliminary remarks may give the impression that I have swung to the opposite pole, but this is not so; what I wish to bring out is the importance of maintaining a wide outlook, my opinion being that it is only by bringing all the different aspects together that we shall be likely to make progress. The amateur naturalist, the professional systematist, and the applied biologist all have contributions of equal value to make to the many problems which nature sets us.

It is impossible to deal with them all in this address, and, moreover, as the attempt would prove tedious to you, I intend to confine my remarks to giving some examples from work in timber mycology, drawing special attention to the great need for systematic work because it is the side which appears to me to have been sadly neglected,

so much so that there is a grave danger that in the comparatively near future there will scarcely be anyone capable of identifying with authority many even of the more common fungi.

Now this side of the work is the one which is most open to the amateur, as it requires little expense in equipment. The only requisite is a microscope, which need not be one of the expensive research models, and even without a microscope much can be done. With the microscope a micrometer eyepiece is required for spore measurement, etc., and when once calibrated with a micrometer slide, direct measurements can be made.

It is to a large extent the fault of the professional mycologist that much of the useful knowledge possessed by the amateur is never made available, as the latter is often made to feel that his observations are of little value. On the other hand, a certain number who possess keen observational powers and have an inborn systematic sense are able to identify plants, but are often unable to analyse the reasons whereby they arrive at a determination, and, therefore, cannot assist others; thus their knowledge often dies with them.

Many whom one might term the hangers-on are content to leave the naming to others and attempt to memorize the species, but this does not lead to any advance in the subject. To only a few, such as our distinguished member, Mr Carleton Rea, is given the ability to know and retain a knowledge of more than a very limited number of plant names, but there is no reason whatever why anyone who is sufficiently interested and possesses the discriminating faculties necessary for systematy, should not become an expert in a limited number of genera.

If this line was pursued, I feel convinced that systematic mycology would come into its own again.

At present we go out and collect as much as we can and then many of us feel that our labours are done, leaving the rest to a few zealous, overworked members, the names of whom it is needless to mention, but to whom we owe the reputation of this Society.

Have you ever asked yourselves what might be the position when they are no longer available? We should be like sheep without a shepherd; a parasite without its host.

I have been disappointed that so few papers appear in our journal of a systematic nature compared with, say, that of our French colleagues, but the remedy lies with all of us.

In the first place I would seriously suggest to members that they form groups, each group concentrating on collecting species of certain genera, and that they should make a special study of these. This is already done with the Myxomycetes and Lichens. I am sure that they would gain a greater knowledge in Mycology in general by this means, and the work would be of inestimable value.

Not being a systematist myself, I feel more at liberty to speak frankly on this subject.

In regard to field work in general, much knowledge of great importance could be obtained if more use was made of a note book. I speak in particular to those members who are lucky enough to live in the country and who have a certain amount of free time available, although much useful work can be done in the neighbourhood of towns, and builders' yards also often prove a fruitful hunting ground, not to mention houses—even one's own home.

Very little work has been done on the ecology of fungi, data over a number of years being lacking. I am glad to say that at Oxford, work of this kind is now being undertaken which should in due course provide much useful information. The kind of work which I have in mind is the intensive study of a limited small area in which all the species occurring are listed; their time of appearance noted from month to month, from year to year, together with meteorological observations such as rainfall. The type of soil and the associated flowering plants should also be noted, and any other factors which may appear to have some possible influence on the mycological flora. By this means valuable data would be obtained which should help to throw light on such questions as fungus distribution, humus formation, mycorrhizal association and many other problems which would assist the forester, the biochemist and the plant physiologist.

A more confined subject for study is the sequence of fungi occurring on fallen logs of different species of timber.

Such data when collected would assist the chemist in fundamental studies of the chemistry of the decay of wood, besides adding to mycological knowledge.

Now what are the characters which have been used as of diagnostic value in distinguishing genera and species?

It is an interesting fact that in fungi specific distinctions are often more definite than are generic ones; this points to the fact that some at any rate of the genera are purely artificial. (I shall refer to this later when I touch on the use of cultural characteristics in systematic determination.)

Distinguishing features

In the first place the general form of the fruit body usually allows one to place the specimen into its main group, that is whether it belongs to the Ascomycetes or to the Basidiomycetes or to any other group; but even here it is sometimes difficult to decide without recourse to microscopic examination, as some Ascomycetes resemble in general appearance certain members of the Thelephoraceae, and some Basidiomycetes, e.g. *Cyphella*, resemble in the form of their fruit

body the apothecia of Ascomycetes. There is little difficulty in deciding, however, provided that the fruit body is mature, for, as we all know, division is based on the manner in which the spores are borne, and microscopic examination will decide this.

It is when we come to separating off the genera that difficulties arise, as there is often a wide variation in a single genus, and supposedly distinctive characters are often absent; in addition it is always a moot point where to draw the line between allied genera, showing again that many of them are separated on purely artificial characters. To take an example or two from the group with which I work:

Merulius as a genus is supposed to be characterized by the fact that the spore-bearing surface is in folds instead of pores or gills; but if the fruit body is in the form of a bracket these folds often develop into teeth, and there is no reason, so far as I can see, why *Merulius lacrymans* should not be considered a perfectly good *Hydnum*; in *Merulius pinastri* teeth are a regular feature. A species recently shown to me, obtained from the Rand mines, which resembles *M. pinastri*, but is probably an allied species, is to all appearances a good *Hydnum*, and yet it is clearly very close generically to *Merulius lacrymans* as regards its general appearance. These species are obviously nearer to *Hydnum* than are *Merulius corium* and *M. tremellosus*, to which species of *Phlebia* approximate very closely, this being further borne out by the close similarity of their behaviour and appearance in culture. The separating off of the types of *Merulius* with coloured spores into *Gyrophana* by Patouillard seems to me a step in the right direction. Again gills in *Paxillus panuoides* may never develop into more than folds or veins, and in such specimens the resemblance to *Merulius* is very close; in fact this fungus was formerly called *Merulius*, and I remember in my earlier days one such fruit body being identified as *M. aurantiacus* by quite a well-known botanist who shall be nameless! The separation of *Lenzites*, *Daedalea* and *Trametes* also appears to be entirely artificial and has been abandoned to a large extent in modern systems of classification, although it is still adopted by most mycologists in this country. In these genera, when grown in culture, one can find all forms of fruit body from *Hypochnus*-like types, through Thelephoroid forms up to the well-recognized normal forms. It would be interesting to ascertain how far some of the abnormal forms occur only when the fungus is grown under artificial conditions or whether they all occur in the field and then have not been recognized as belonging to one and the same species or genus.

The general colour of the fruit body appears to be more constant, although even here there may be wide variations and one may get almost colourless forms of a normally coloured species in many Agarics and in some Polyporaceae. Forms of *Polystictus versicolor*

occur, especially when the plant is growing in reduced light, in which the typical colour and zonation may be almost lacking.

Spore colour, which is one of the main characters upon which generic distinction is based amongst the Agarics, is more or less constant, although some genera include species with both coloured and uncoloured spores, and probably to those who know these plants, examples will come to mind where spore colour alone cannot be relied upon.

In the Polyporaceae the presence or absence of coloured setae is used as a diagnostic feature, but caution has to be used, as specimens may be found possessing no setae, in species in which their presence is taken as a diagnostic feature separating them from another species.

The form of the fruit body in the Polyporaceae may be very varied, resupinate forms often occurring even in species which are typically bracket-shaped, e.g. *Polyporus adustus*, *Phellinus cryptarum*, *Polystictus versicolor*, *Poria Vaillantii*.

I have collected resupinate forms of *Phellinus cryptarum* which consisted of very shallow pores, more resembling folds, whereas typically it forms a large stratose bracket or a thick resupinate pad with well marked small pores. Again in *Poria Vaillantii* I have collected very fragile soft thin *Poria* types, as well as thick *Polyporus* types much more tough in consistency, with pores quite one inch long. There is no doubt of their identity, as this fungus has well marked characteristics when grown in culture and in addition, spore size and other characters agree. In the Agaricaceae we all know the difficulty at times of deciding whether the gills are decurrent or not, and as an ignoramus regarding most agarics, it often appears to me that identification depends more on knowing the plant than on the use of keys, which are apt to be of little use except to those scarcely needing them, owing to the wide variation even within a single species between individual specimens.

The consistency of a stem, i.e. whether cartilaginous or not, depends to a certain extent on climatic conditions at the time of formation, and even the presence or absence of a ring may be difficult to decide, as in some species of *Pholiota*. In addition, the use of this last named character in separating genera may lead to separation of closely allied if not identical species; I will only mention *Armillaria mellea* and *Clitocybe tabescens*, the former with a ring and the latter without it.

Microscopic characters

With regard to microscopic characters, I will deal only with the wood-destroying Hymenomycetes with which I am personally familiar. These following characters are used mainly for specific diagnosis: whether the hymenium is homogeneous with the trama or forms

a separate layer, and the presence or absence of setae, but the latter, as has been pointed out, is not an entirely reliable character. The average size of the basidium may vary considerably, and before basing much reliance on this a great number of specimens should be examined from different localities. In some of the white species I have found a great variation from dumpy, sub-spherical basidia, which are often characteristic of resupinate forms of normally bracket-shaped species, to normal elongated ones (*Polyporus fragilis*).

The length of the sterigma is often a useful accessory aid.

Spore size is perhaps a less variable character with the proviso that care must be taken to measure mature spores from basidia bearing the normal number of spores for the species, and in this connexion it is interesting to note that in the Agarics two-spored and four-spored forms of the same species occur, the two-spored forms being characteristic of the species from one locality and four-spored forms from another. This is true only of certain species, others have constantly two or four spores from whatever locality they are collected. It would be interesting to investigate whether some of the former in which the two types occur, are in reality hybrids.*

I do not know whether here there is a difference in spore size between the bi-spored and tetra-spored forms of the same species. Corner described two species of *Hygrophorus* from Malaya having both small and large basidia and spores in the same fruit body.

In the white species of *Polyporus* the occurrence of basidia forming an abnormal number of spores is fairly frequent at any rate for *P. fragilis* and *P. lacteus*. Normally both these species bear four spores, but specimens occur in which two-spored basidia are frequent, and even one-spored basidia occur. If measurements are made of these spores they will often be found to be larger than spores from normal four-spored basidia, this being probably due to divisions of the nucleus being omitted.

Both these species belong to the group which have narrow, slightly curved allantoid spores, and the spores in the abnormal specimens may lose this characteristic and become more typical of *Polyporus albidus* or even of *Poria sericeo-mollis*, so that if this character was taken alone, an entirely wrong determination might be arrived at.

Spore size overlaps a great deal, and is often identical in many of these species, so that it is only of assistance in narrowing the field. Whilst talking about spore size I would like to impress on workers the importance of stating in what condition the spores are measured and also the number on which the average size is based; mention

* In a note entitled "Remarques sur la valeur taxonomique de la bisporocité chez les champignons supérieurs" Marcel Josserand recorded that *Mycena rorida* was bispored in one region, in Denmark both forms occurred, whilst *M. speirea* was always bispored.

of this is almost invariably omitted, and it may make a considerable difference whether the spores were measured dry, in water, in potash, or some other mountant; I would like to see a standard agreement arrived at on the method to be adopted, so that measurements by different authors would be directly comparable.

The arrangement of the hyphae in the sub-hymenial layer is a better character for separating some of the white species. In some species the general arrangement is in a direction parallel to the surface of the fruit body, whilst in others it forms a meshwork at an angle of 45° or more. Even here, there may be variation, and if sections are examined from the curved portion of a bracket-shaped fruit body, the arrangement in a species characterized normally by parallel arrangement may be a meshwork, e.g. in *Polyporus lacteus* the hyphae are usually regular and more or less parallel, but in *P. fragilis* a meshwork is formed. The presence or absence of clamp connexions is a fairly constant character, provided that this distinction is not taken too literally; by this I mean that in species in which clamp connexions are said to be absent odd clamps may often be found by diligent search. Thus it would be preferable to state that clamps are abundant, as compared with clamps rare or absent. In *P. lacteus* clamps are rare, in *P. albidus* scattered, in *P. fragilis* very numerous.

Staining reactions with iodine and other reagents are used by certain workers; the trama in *P. albidus* stains yellowish brown and iodine is frequently used for diagnostic purposes in the Discomycetes. I have had very little experience myself, but such tests are probably usually reliable; they should be used with caution, as the reaction might well vary according to the condition of the specimen; the presence of other micro-organisms might affect the reaction.

Discoloration on touching or bruising as in *P. fragilis*, which becomes spotted red or fuscous, and the blue coloration of *P. caesius*, is reliable as far as it goes, but a negative result is of very little value, as so much depends on the condition of the fungus when gathered, and here again the presence of bacteria, etc. may affect the reaction. In this connexion it appears possible from some recent work carried out in my laboratory by Dr Ernest, that many of these fungi may have bacteria associated with them which cannot be separated by the usual methods of technique, as they possibly live in the mucilaginous hyphal wall, and, therefore, they almost form part of the fungus.

The host plant is often of great assistance, and those who specialize on Pyrenomycetes find, I believe, that identification can mainly be based on identification of the host plant.

The Polyporaceae are not so specific, many of them occurring on a number of hosts, not necessarily confining themselves to either Dicotyledons or to Conifers. Often they may fruit better on one host, and it is, therefore, a question whether the mycelium may not occur

unrecognized on other hosts and that some chemical or other difference in certain hosts militates against the formation of sporophores. I shall refer to this again when discussing the use of cultures for diagnostic purposes.

From the collector's point of view the only part of the fungus that matters is the fruit body, but from an economic standpoint it is the mycelium that does the damage.

It might be possible to identify many or all fungi forming an external mycelium from that alone if an intensive study was made with this end in view, although it would not be so easy as in flowering plants in the absence of flowers. A study of mycelial characteristics would prolong the period of activity of the field mycologist. Knowledge of such characteristics might extend our insight also into the various relationships existing between the higher plants and the fungi.

With many of the lower fungi and with bacteria, identification is usually based on the behaviour of the organisms when grown on standard culture media in the laboratory. This is usually unnecessary for the higher fungi, that is, if either a typical fruit body is present or the external mycelium is available in those species which produce characteristic growths. Nevertheless, cultures are proving of great assistance where there is some doubt as to the identity of the fungus, either because of abnormality or in dealing with closely allied species, in which there is some uncertainty whether they are forms of one species or are entitled to specific rank. For instance the question whether *Armillaria mellea* and *Clitocybe tabescens* are distinct or not might well be decided by comparison of their behaviour in culture, and it is by the aid of cultures that it should prove possible to link up some of the resupinate species of *Poria* with *Polyporus*. Another method is by crossing monosporous cultures of each species, a method likely to prove of special use in such a group as the white species of *Polyporus*, many of which are obviously closely allied, if not identical.

It is not to be expected that the field mycologist will be able to carry out this type of work, as laboratory facilities are necessary, and it is here that another important liaison should be established between the field worker and the worker in the laboratory by drawing attention to, and if necessary providing material of, species about which there is some doubt and on which culture work would appear to be desirable. In my own work I have received specimens from several members, and shall always be grateful for such help. The use of cultures should help to clear up many systematic troubles.

In work on timber decay, and especially in advisory work, fruit bodies of fungi causing decay are present only in a small proportion of the specimens. It would be of little use to delay reply until fructifications might be obliging enough to develop on the samples as this might mean a delay of several years; although departmental delay is taken as a matter of course, I fear that the period of grace would

be often very much strained. It may be thought that it is of very little importance to an enquirer to have the fungus identified, as one fungus is much the same as another from the timber users' point of view, but the enquirer very often desires to know when the infection started, for the settlement of claims which may amount to considerable sums of money may depend on a correct determination of this.

For instance, a parcel of timber is inspected on arrival and shows decay which may be in the incipient stage: or some discoloration may be present. The enquirer wants to know in the first place whether this is due to fungus, and if so, whether the timber was infected during transit, or at what stage it was infected. Upon this depends whether the shipping company or lumber firm is to be held responsible.

Again, the timber in a newly built house may show signs of rot soon after erection and the builder is blamed. He naturally tries to pass on the blame to the timber merchant and the timber merchant on to someone else in the time honoured way traditional of the army.

Another trouble concerns motor bodies exported from this country developing decay in the woodwork shortly after being put into service. The purchaser lays the blame on the manufacturers, suggesting that the timber used was already infected.

In all such matters the identification of the fungus provides the main evidence for the settlement of responsibility on the right shoulders.

If on making cultures a fungus develops which occurs only as a heart rot of the standing tree, it shows that the timber used was already infected. Again, some cultures from defective wood showed the fungus to be *Polystictus sanguineus*, and in other cultures *Lenzites striata* developed. These species do not occur in this country, so that infection had occurred in the country of use and was not, as was contended, due to the use of ash timber infected in this country before manufacture. In house timbers, Douglas fir sometimes shows pockets of brown rot soon after the erection of a house, and the builder is naturally blamed for this. This type of rot may be scarcely visible until the timber begins to dry out, and, therefore, the owner thinks quite naturally that an outbreak of some form of dry rot has started, whereas the fungus causing this type of decay is not a common one in this country and almost always the infection was present prior to shipment.

Identification of the cause of "brown oak" was obtained by means of the culture method, and thus a ready means of picking out trees from which brown oak can be obtained is available to the timber merchant. The proof that *Stereum sanguinolentum* is the fungus associated with *Sirex gigas* was obtained in a similar manner. Many other examples could be given, but sufficient have been cited to indicate the importance of identification.

Cultural characteristics of diagnostic value

It may be thought by those accustomed to think of fungi in terms of fruit bodies that the vegetative characters are very much alike for a great number of species, and that, therefore, distinguishing features would be absent; but when it is remembered that most flowering plants, even closely allied species, may be easily identified in their vegetative state, I think that it will be agreed that there is no reason why fungi should not also develop characteristic types of growth.

With a number of species the growth in culture is quite as distinctive as the fruit bodies, as for example in *Polyporus sulphureus*, *Poria Vaillantii*, *Merulius lacrymans* and *Lentinus lepideus*, to name only a few. All these, once seen, can easily be recognized from the general type of growth or the colour when grown on a malt agar medium.

Others may appear closely to resemble each other in general appearance, but it is surprising how many of them can be separated after one has handled them for some time, even though at first sight they may appear similar.

Where there is a difficulty in separating the mycelium on general characteristics, examination under the microscope will usually bring out characteristic features for each good species, and when two cultures isolated from supposedly different species appear to be identical, my experience has been either that there has been a misdetermination of one of the original fruit bodies, or that there are good grounds to believe that the two are merely forms which should be included under one species. It is of course necessary, as the original identification is based on the sporophore, to obtain isolations from authentic material for comparison, and in my laboratory we keep a collection of such cultures for this purpose.

Here I would add a warning that one cannot be too careful as to the authenticity of the original material, and, therefore, no culture should be accepted except that obtained from material identified by a dependable authority, otherwise one may lead other workers using the culture for subsequent research work into grave error, which may remain undetected for years. An example of this has come to my knowledge in the standard fungus used for preservative tests in America. I refer to *Fomes annosus*, Madison Strain No. 517, which is stated to have been isolated in 1910 from wood showing decay by this fungus.

On receipt of this culture we noticed that it differed from the typical culture of *Fomes annosus*, as isolated by us and by continental workers: *F. annosus* has a very characteristic growth, and in addition produces the conidial form pictured by Brefeld under the name of *Heterobasidion annosum*. We therefore felt convinced that it could not be *Fomes annosus*.

Further, although growing actively on hardwoods it did not flourish on softwoods. We found that it resembled closely a culture of *Polyporus tulipiferus*, a species occurring in Canada and U.S.A. on hardwoods, and in due course small fruit bodies were formed on beech blocks which appeared to be those of *P. tulipiferus*.

Another example was that of a culture labelled as *Polyporus destructor* which was sent to us; this proved to be *Polystictus versicolor*!

In the absence of characteristic growths, microscopic distinguishing features will usually be found. Examination of the aerial and of the submerged mycelium will generally bring out features which assist in identification, provided a standard culture is available for comparison. The following are a few of the main characters which have been found useful:

(1) The type of branching of the hyphae and the frequency of septation. In some the hyphae come out at a wide angle, and in others they tend to turn up and run parallel with the parent hypha. In a few, as for example in *Polyporus Schweinitzii*, there is a strong tendency for them to turn down and then run parallel to the parent hypha.

(2) The average diameter of the hyphae is rarely helpful, as it is similar for many different species. In some, large hyphae with contents or with thick walls may be present amongst smaller hyphae, and they may have few or no septa and be curiously branched, e.g. *Polyporus fragilis* and *P. fuliginosus* (*P. benzoinus*).

(3) Presence or absence of setae.

(4) Presence or absence of clamp connexions, and their form, size and distribution, whether in whorls or occurring singly. *Coniophora cerebella* and several species of *Stereum*, e.g. *S. hirsutum*, show whorled clamps.

The presence of a special type of clamp known as a "medallion" is a characteristic of certain fungi, as for example *Lenzites sepiaria*, *Paxillus panuoides*, *Lentinus lepideus*, but these latter are rarely if ever formed on agar, being seen, however, in sections of wood attacked by the fungus; also they are present occasionally in many species not reported to have them, e.g. *Poria Vaillantii*.

(5) Irregular shaped swellings on the hyphae, often more pronounced in the submerged mycelium, are characteristic of some species.

(6) Secondary spores, either chlamydospores or conidia, are formed abundantly, either in the aerial mycelium or in the submerged, or in both, in a number of species as, for example, *Fomes fraxineus*, *Pholiota adiposa*, *Trametes serialis*, *Fistulina hepatica*, *Fomes annosus* and *Polyporus sulphureus*.

(7) Presence and type of crystals in the medium may be helpful at times.

There are a number of other points which will be found to assist in identification, but sufficient has been said to show that differences in culture may be quite as pronounced as in the fruit bodies.

It has been shown that *Lenzites trabea* and *L. thermophila* are synonymous and that the fungus known by most mycologists in this country as *Poria vaporaria* is in reality *P. Vaillantii*. Of course there is some variation within a species, but so far it has been found that the main characteristics are fairly definite.

In such a difficult group as the white species of *Polyporus* the culture method should prove very useful in corroborating identification made in the field.

Physiological distinctive characteristics

If the general characteristics, including colour, texture and microscopic features, afford insufficient evidence on which to make an identification of a doubtful species, it is often possible to obtain further evidence by growing the fungus on several different media, as many species which appear identical on one medium, may show great differences when grown on another of different constitution. For instance a negative character is that certain fungi will not grow readily except on a medium with a *p*H on the acid side of neutral; an example of this is *Polyporus fragilis*, and others behaving in a similar manner are *Paxillus panuoides* and *Fistulina hepatica*. In some the development of colour in the mat is encouraged by exposure to light, whereas in others it only develops fully in the dark.

The effect of light on the rate of growth is very pronounced in certain species, and *F. hepatica* exemplifies this also, hardly growing when exposed to light, and never in my experience fruiting, whereas in the dark or in very subdued light it grows much more rapidly and fruit bodies are formed readily. If such cultures which have initiated a fruit body in the dark are brought into the light, further development is usually arrested.

The rate of growth at different temperatures is often a useful aid to identification, and the temperature maximum has proved of great use; thus for example *Merulius lacrymans* can be readily separated from the supposed wild form *M. sylvester*, the latter having a much higher temperature optimum. The formation of fruit bodies under certain conditions often allows of easy identification, even although such fruit bodies may be unrecognizable to the field mycologist. The spores in such fruit bodies and the basidia are usually normal in size for the species and the spores are viable.

Further examples of the use to which the culture method is employed in our work at the Forest Products Research Laboratory are furnished below.

An investigation was asked for into the cause of decay in lifeboats. A number of boats were examined, in which serious decay had taken place. The rot present was found to be of three types: a brown cubical rot which occurred in the oak members such as crooks, stem, stern posts, etc.; a brown rot of the *Coniophora* type, in which cubical cracks were small, but with more pronounced longitudinal shrinkage cracks occurred in the softwoods and also to a certain extent in the smaller members, such as ribs, gunwales, etc. made of hardwoods; rarely a white stringy rot was also found.

Fruit bodies were never present, and although one could make a guess at the possible identity of the fungi concerned, it would not have been possible to name any of them with certainty.

Cultures were made, and it was proved that *Polyporus sulphureus* was the cause of the brown cubical rot. This had already been suspected, as material which was being cut up in a boatyard showed the earlier stages of this type of rot. From this I was able to state that timber containing hyphae of this fungus had been used, and that infection had almost certainly taken place in the standing tree. Such timber had been included in all good faith, as those concerned had not realized that in order to exclude infected material they must cut away well beyond all visible sign of attack. As you all know, this fungus is common on old park oak trees, and it is only from this type of tree that crooks in large sizes can be obtained.

The other brown rots were shown to be caused either by *Poria* spp. or by *Coniophora cerebella*, and as decay was often found to have started adjacent to bolt holes, the probability that infection gained entrance during service became almost a certainty. From the white rots in hardwoods, *Polystictus versicolor* was isolated a number of times, and *P. sanguineus* from some boats which had been in service in tropical waters.

If the fungi which are principally concerned in the decay are known, one is in a much better position to advise as to the best and most economical preservative to use in order to protect the timber against attack, for fungi vary greatly in their resistance to different chemicals. For instance *Lentinus lepideus* can tolerate a 5 % solution of creosote in wood, whereas most fungi would be killed at a much lower concentration. Some such as *Lentinus*, are very sensitive to zinc salts, whereas *Coniophora* is resistant to them, and, therefore one would never advise the use of zinc chloride where *Coniophora* was the fungus concerned.

The fungi occurring in mines afford another excellent example where the field mycologist would be at a loss to identify many of the

species present. Owing to the abnormal conditions of light and the presence of abundant moisture, the fruit bodies are usually entirely aberrant in form and often lack their normal colours.

Many species in mines remain in the vegetative condition partly because of lack of light, but probably mainly because of the uniform conditions of temperature and moisture. Culturing provides the quickest and most sure method for identifying these forms. Examples of these abnormal forms are numerous, e.g. the curious sterile stag's-horn-like structures formed by many species of *Lentinus*, and by *Polyporus sulphureus*; the many forms assumed by species of *Poria* and by *Fomes annosus* (though these latter are usually easily recognizable) and the white or cream-coloured forms of *Polystictus versicolor*, which often show little or no zonation.

One example may be given in which the culture method has led to the proof that a fungus rarely reported as occurring in this country has been shown to be present sometimes in the vegetative condition. This was in connexion with an investigation which Mr Peace was carrying out on behalf of the Forestry Commission, a survey being made of the fungi causing butt rots in conifers. As fruit bodies were not often present, cultures were made from the wood, and many were sent to me for assistance in identification. Among these cultures, one isolated from *Thuya* growing at Benmore, Argyllshire, proved to be identical with a culture of *Fomes pinicola* received from Ottawa and isolated by Dr Mounce. (Incidentally, this same fungus was obtained from some Hemlock imported for use as rail sleepers in this country; some of the timber was sent to us and some to Canada by the Railway authorities for identification of the cause of the rot. We informed them as a result of our identification that the timber was certainly infected before importation. We heard afterwards that they had received a similar reply from the Canadian side.)

Other rather unexpected fungi which were isolated from living conifer butts were *Hypholoma fasciculare*, *Merulius himantioides* and *Coniophora Bourdotii*. Several cultures appear to be *Spongipellis spumeus*, identification being based on the size of the pores formed in the rather abnormal fruit bodies developed in culture. We have not managed to obtain a comparative culture, attempts at isolation having so far failed, possibly owing to the high bacterial population in most of them.

There are many interesting investigations awaiting anyone who wishes to take them up; some of them purely of mycological interest, such as the many forms of micro-fungi occurring on wood, which are not of direct economic importance, and, therefore, cannot be investigated by us. I have no doubt that any student would be able to add not only to the list of British fungi, but would discover also many hitherto undescribed forms. Some of these would be found to be of some economic importance in that they might cause dis-

coloration of the wood, and in addition they might be found to affect the wood in such a way as to make it more readily attacked by some of the higher fungi, and also by wood-destroying insects.

In conclusion, returning to my original theme concerning the need for the encouragement of systematy, I would like to suggest that members should wherever possible join their local natural history societies, as by so doing they would be able to encourage younger members to interest themselves in field mycology. Thus they would be acting as missionaries, and our knowledge of the distribution of the fungi in the British Isles would be increased.

Whilst talking about such societies, I should like to see them assisted in such a way that the results of their labours might be put to their full use.

In most of these societies there are keen members with considerable local knowledge, but owing to lack of encouragement from official quarters much of this knowledge is never put on record, and thus is lost.

Would it not be possible for societies such as ours and others interested in other branches of biology to prepare forms with headings giving the sort of information which was required, with suggestions as how best to record such information?

The societies should be encouraged to get their members to use such forms and these could be sent up to what one might call the parent society. I feel sure that much useful data would be obtained which would help greatly in the better understanding of many biological problems.

Of course I fully realize that there are many difficulties in organizing such a scheme, and many of us no doubt feel ourselves already fully occupied, but on the other hand at some time or other we come to retiring age, and it appears to me that if one has the matter really at heart, one could then undertake a part of such organizing.

It was many years ago that I first discussed the possibility of such a scheme. I am glad to see that recently there has been formed an "Association for the Study of Systematics in Relation to General Biology", the aims and objects of which cover much of the field I have indicated, and actually No. 8 on the agenda list reads as follows: "To suggest useful lines of biological work to Natural History Societies and to amateurs, and to assist in its co-ordination."

It would lessen the work of any one individual if the country was divided up into areas according to the compass points, e.g. Western Counties, and much could be done through the County Associations where these exist, apart from local natural history clubs. Small committees could be formed representing the different branches of natural history, and these could get into touch with and obtain guidance from societies such as ours, through the Association. In

addition I feel sure that research stations and others would be prepared to help as far as their time permitted, and they would on their part find that the data thus obtained would prove a good return on any trouble they had taken initially.

On this matter I am, of course, only voicing my personal opinion.

It appears to me that in ecological work in particular the data which could be obtained, were such a scheme in working order, would prove of the greatest value.

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THE IDENTITY OF *HYSTERIUM CLADOPHILUM* LÉV. AND *H. VACCINII* CARM.

By A. S. BOUGHEY, B.Sc.

(With 3 Text-figures)

The name *Hysterium cladophilum* was given to a species of *Hysterium*, no. 1243 in Moug. & Nestl. *Stirp. Crypt.*, by Léveillé in 1850, but does not appear to have been accompanied by a description.

The first account of the fungus is given by Duby (1861) under the name *Sporomega cladophila*. *Hysterium cladophilum* Lév., and also *H. Vaccinii* Carm. are cited as synonyms.

A more accurate description of *H. cladophilum* Lév. is supplied by Rehm (1887), who recognizes the fungus as a *Lophodermium*, and includes as synonyms *Sporomega cladophila* Duby, *Hysterium cladophilum* Lév., and *H. Vaccinii* Carm.

The fungus has recently been transferred to the genus *Bifusella* by Tehon (1935), who renames it *B. Vaccinii* (Carm.) Tehon.

As can be seen, therefore, some doubt exists as to the exact nature of *Hysterium cladophilum* Lév. While an investigation to determine the real identity of this fungus was being made several interesting facts in regard to *H. Vaccinii* Carm. were brought to light.

H. Vaccinii was described by Berkeley (1836), while *H. cladophilum* was not named until 1850. Assuming that the two names refer to the same species the epithet *Vaccinii* has priority. Duby (1861) states that he allows the epithet *cladophilum* to supersede *Vaccinii*, not because of any doubt as to the validity of *H. Vaccinii*, but because, with *Sporomega degenerans* also occurring on *Vaccinium* the epithet *Vaccinii* might lead to confusion. Other authorities follow Duby without any discussion as to priority of specific epithets.

A specimen of *Hysterium Vaccinii* Carm. is in the Herbarium at Kew, and is labelled as the type. When this was examined, however, it was found to be a species of *Gloniopsis* and not a *Lophodermium*. That Duby, who indicates that he examined a specimen of *Hysterium Vaccinii* Carm. sent to him by W. J. Hooker, should not have recognized this is inexplicable, unless he received a different fungus. Nor is it any more easy to understand why Rehm, Massee, Cooke, Tehon, and others who cite *H. Vaccinii* as synonymous with *H. cladophilum* should not have examined the type specimen of the fungus; it was certainly available to Cooke and Massee.

As *H. Vaccinii* appears to be a species of *Gloniopsis* hitherto undescribed, a description is given below.

Gloniopsis Vaccinii (Carm.) comb. nov.

Hysterium Vaccinii Carm. in J. E. Smith's *Engl. Fl.* v, pt. 2, p. 295.

Hysterothecia straight or curved, naked, black, scattered, at all angles to the stem, when mature projecting prominently, surrounded at the base by the ruptured epidermis, 450–820 × 220–320 μ, slit occupying practically the whole length. Asci cylindric-clavate, 90–110 × 13–15 μ, shortly stalked, apex rounded, wall thick; spores 8, elliptical, 20–25 × 8–10 μ, faintly constricted at the middle into slightly unequal halves, hyaline, smooth, 5–6 septate then muriform. Paraphyses filiform, branched and coloured above, forming a yellow epithecium.

Text-fig. 1 *a*

Text-fig. 1 *b*

Text-fig. 2

Fig. 1. Single ascus of *Gloniopsis Vaccinii*. *a*, immature, ascospores still only partly septate; *b*, mature, ascospores muriform. × 1000.
Fig. 2. Ascospore of *Gloniopsis Vaccinii*. × 2000.

On stems of *Vaccinium Myrtillus* Appin. Carmichael.

Berkeley's description of *Hysterium Vaccinii* is sufficiently broad to apply to a species either of *Lophodermium* or *Gloniopsis*. *G. Vaccinii* as described above is, however, very similar to *G. levantica* Rehm, and may prove to be merely another form of this fungus, which is given by Saccardo as occurring in Britain on *Rubus*. In this event the name *Gloniopsis Vaccinii* would have priority over *G. levantica*.

There has been a tendency of late for the position of the fructification of certain genera within the tissues of the host plant to be used as a criterion in classification. In this connexion it is interesting to observe that, of the two hysterothecia of *G. Vaccinii* examined, one

was subcuticular, while the other was sunk under two or three layers of cells. So far as *G. Vaccinii* is concerned the position of the hysterothecium within the host tissue would therefore appear to be a not very constant feature.

Mougeot & Nestler's specimen of *Hysterium cladophilum* Lév. is a true *Lophodermium*, as can readily be seen from Fig. 3. Rehm's description is fairly accurate except as regards the length of the asci and spores, which he states are only about half of their actual size. Possibly Rehm took these measurements from immature specimens. The unusual length of its asci and spores (100–140 and 70–90 μ respectively) constitutes a distinguishing feature of *L. cladophilum*. Also the ascospores typically do not extend to the base of the mature ascus.

Fig. 3. Mature ascus of *Lophodermium cladophilum*, showing long thread-like ascospores terminating somewhat short of the base of the ascus, which contains disintegrating epiplasm. × 1000.

The following British specimens of *L. cladophilum* Rehm have been examined. All occurred on stems of *Vaccinium Myrtillus*:

Hysterium maculare Fr., Berkeley, Penzance (Kew); Berkeley, Notts. (Kew); *Sporomega cladophila* Lév., Llyn Gwymon, nr. Dolgelly (Brit. Mus.); Trail. Denmore, nr. Aberdeen, 1887; Aberdeen Univ.; *Lophodermium cladophilum* Rehm, Wilson, Corrour, Inverness-shire, 1923 (Roy. Bot. Gard. Edinburgh).

I also found the fungus in some quantity on *Vaccinium Myrtillus* at Dawyck, Peeblesshire. In February, when the material was collected, the asci were still immature, but ripened in an unheated greenhouse the following April.

A number of foreign specimens, have been examined all on stems of *V. Myrtillus*. These were:

Sporomega cladophila (Lév.) Duby, 373 Kunze, *Fungi sel. exsicc. Zurich*, 1878 (Kew and Brit. Mus.); 3566 Rab-Win., *Fungi europ. Belgium* (Kew); 346 Roumeguère, *Fungi selec. Gall. exsicc.* (Kew); *Lophodermium cladophilum* (Lév.), 2420 Sydow, *Mycotheca Marchica*, 1888 (Kew, Brit. Mus. and Aberdeen Univ.).

A number of other specimens either contained no mature fructifications, or the small number of the latter did not permit the removal of any for examination. These were:

Sporomega cladophila Duby, 1967 Fuckel's *Fungi Rhenani* (Kew and Brit. Mus.); 507 von Thümen, *Fungi austr.* (Brit. Mus.); *Hysterium cladophilum* Lév., Rab. *Fungi europ.* (Brit. Mus.); Desmaz., *Plant. Crypt. France*, Ser. II, 1853 (Brit. Mus.).

Two American specimens on *Vaccinium corymbosum* were also examined:

Sporomega cladophila Duby, Ellis, 154 *N. Amer. Fungi*, 1878 (Kew); *Hysterium*, 2542 in Herb. Cooke (Kew).

These two were not *Lophodermium cladophilum* Rehm, although somewhat similar. The hysterothecia were consistently narrower than those of this species. Also the fructifications tended to lie with their long axes at right-angles to the axis of the stem, and to project more from the overlying cuticle than in *L. cladophilum*.

Hysterium cladophilum Lév. appears in both Cooke's and Massee's British fungus floras. Cooke (1871) copies Berkeley's description, adding "asci cylindrical, sporidia filiform, hyaline", but supplies no measurements. His illustrations are a little obscure. Massee (1895) gives a fairly accurate description, but makes the asci only 40–50 μ long. Both he and Cooke quote a passage from Berkeley which suggests that the overlying cuticle is eventually shed from the hysterothecium. This has not been observed in any of the species examined, and is not believed to take place.

Grove (1922) states: "...*Lophodermium cladophilum* Rehm, of which *L. melaleucum* should probably be considered merely the leaf-form." This is not correct. *L. melaleucum* is a distinct species, and although usually found on the leaves of *Vaccinium* may also occur on the stem.

As regards the occurrence of *Hysterium cladophilum* Lév. in America, Ellis & Everhart (1892) give *Lophodermium cladophilum* as occurring on *Vaccinium pennsylvanicum*. Their description of the fungus is sufficiently broad to include any *Lophodermium*, and is practically a translation of Duby's account. Reference to the ascospores as "about as long as the asci" makes it doubtful whether the specimen was *L. cladophilum*, where, as previously stated, the ascospores typically do not extend to the base of the mature ascus.

In his recent monograph on the genus *Lophodermium*, Tehon (1935) finds that *L. cladophilum* is not a true *Lophodermium*, and places it in the genus *Bifusella* as *B. Vaccinii* (Carm.) Tehon. Although Mougeot & Nestler's specimen of *Hysterium cladophilum* is quoted (qualified by a query) as the type of *Bifusella Vaccinii*, Tehon apparently did not examine this, or, indeed, any other European specimen. The only specimen of *Lophodermium cladophilum* he indicates he examined is *Reliquiae Farlowiana*, no. 46, and this, no doubt, is his *Bifusella Vaccinii*. Unfortunately, it was not possible to examine this specimen. Certainly, however, neither *Hysterium Vaccinii* Carm. nor *H. cladophilum* Lév. in Moug. & Nestl. *Stirp. Crypt.* no. 1243 in any way approximates to *Bifusella Vaccinii* (Carm.) Tehon, as figured and described by Tehon. Nor can the specific epithet *Vaccinii* (Carm.) be legitimately applied to this *Bifusella* specimen.

Hysterium cladophilum Lév. is thus a good species of *Lophodermium*,

L. cladophilum (Lév.) Rehm. It is widely distributed, though rare, through Britain and Europe, on the stems of *Vaccinium Myrtillus*; there is, as yet, no definite record of its occurrence in America.

The writer wishes to thank Dr Malcolm Wilson, at whose suggestion this investigation was carried out; also the Director of the Botanic Gardens, Kew, the Keeper of Botany, British Museum, and Prof. Matthews of Aberdeen, for facilitating the examination of certain herbarium specimens.

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ON THE "SCLEROTIUM" OF *COLLYBIA FUSIPES* (BULL.) BERK.

By A. H. CAMPBELL

(With Plate XIV)

I. Introduction

The common spindle-stemmed agaric, *Collybia fusipes* (Bull.) Berk., is frequent at the base of trees and stumps of oak (*Quercus Robur*) and beech (*Fagus sylvatica*) during the summer and autumn. The fusiform stipe, from which the fungus derives its specific epithet, is cartilaginous, sulcate, twisted and, in mature specimens, hollow, ventricose and markedly attenuated towards either end, particularly at the base. The sporophores are generally clustered, indicating their origin from a common source; they may arise directly from the wood of the tree or stump or apparently from the soil around it. Much interest has centred in their origin; they have been variously described as arising from a sclerotium (Léveillé, 1843), from the stalk of the previous year's mushroom (Léveillé, 1843), from the mycelial strand formed by the fusion of several stipe-bases of previous years (Fayod, 1889) and from a "perennial pseudorhiza" similarly composed (Buller, 1934). This investigation was designed to elucidate the nature of the structure from which the sporophores of *Collybia fusipes* arise.

Bulliard (1784) first described this fungus as *Agaricus fusipes* and figured one large and three small sporophores arising from a small, apparently spherical, black body the nature of which he does not mention. The black body, however, looks so much like a sclerotium that a number of writers have declared it to be one. Léveillé (1843) stated his belief that the tubercle from which the sporophores arise may be a true sclerotium as he himself had met with it several times in this state. He pointed out that this sclerotium was not constant in occurrence but that, more often, the stipe was attached to dead roots or old pieces of wood buried in the soil. The fungus, too, if found in a certain place one year, would almost certainly reappear at the same place in the following season. When such sporophores were dug up carefully to ensure that their attachments were not severed, a black fungous body, elongated and irregular in shape, was exposed, which, he believed, was not a sclerotium but the stipe of last year's sporophore which had given rise to the new mushrooms and was thus acting as a sclerotium. In the following year the stipes

of the present sporophores would, in turn, act as a source for the new growth: so that the *Collybia fusipes*, which had its stipes deeply buried underground, would, in the course of three or four years, end by being at the surface. A plate illustrates Léveillé's remarks and its legend describes *C. fusipes* as arising from the remains of a stipe of the previous year. The figure shows two sporophores arising from a black, many branched, cylindrical body which is marked to demonstrate that it was formed by the joining of a succession of stipes, indicating four years of existence. The body which he illustrates seems to be fairly uniformly cylindrical and it is difficult to see from the figure what justification there is for the statement that it consists of the attached stipes of four successive years' growth.

Fayod (1889) introduced the term "pseudorhiza" to supplant that of "rooting-base" which, previously, was used to describe the subterranean prolongation of the stipe of many agarics, particularly that of *C. radicata*. This author stated that the stipe of several species, including that of *C. fusipes*, is attenuated in the form of a pseudorhiza but that, in *C. fusipes*, this structure is of different origin and must not be confused with the true pseudorhiza. He added that he had never found anything in this species but a thick, mycelial strand formed by the suture, or more rarely by the fusion, of the bases of several sporophores. Fayod seems to have accepted Léveillé's explanation of the origin of the mycelial strand, with the modification that the strand was not derived from solitary stipes but from the union of stipe-bases, of which there is likely to be a considerable number in this caespitose type of growth. Buller (1934) gave a fuller account of this aspect of the biology of *C. fusipes*. He stated that the black, subterranean body, from which he found sporophores arising, is a modification of a pseudorhiza. This he described as a "perennial pseudorhiza" derived from the fusion of the stipe-bases of a previous crop of sporophores. In view of Fayod's (1889) distinction between stipe and pseudorhiza (p. 208), it is surprising to find the term pseudorhiza used to describe a part of the stipe of *C. fusipes* without some explanation of an interpretation which completely reverses that of the originator of the term. It would appear, therefore, that Buller's term "perennial pseudorhiza" is based either upon a misunderstanding of Fayod's definition or upon some other definition of the term "pseudorhiza" of which he gives no indication in his paper.

Apart from the principal works already mentioned, there are a number of reputed illustrations of *C. fusipes* showing sporophores arising from such a black body as that with which we are concerned. Buller (1934) describes the earliest of these, in the Codex of Clusius of about the year 1578. Schaeffer (1762) illustrates in his Plate 87, fig. 1, a young fructification of *C. fusipes*, under its former name of

C. crassipes, arising laterally from a black strand and, in fig. 4, a group of sporophores arising from an elongated black strand. Bulliard's (1784) Plate 76 of *Agaricus fusiformes* (*C. fusipes* var. *oedematopus* (Schaeff.) Fr.) shows a number of sporophores arising from a black, apparently spherical mass, very similar to a sclerotium. It has a massive appearance and is about ten times the size of the alleged sclerotium in his figure of *C. fusipes* on Plate 106. Plate 36 (*C. fusipes* var. *contorta* (Bull.) Gill. & Lucand) shows a number of sporophores arising from a thick, black, obconical structure. In the Herbarium at Kew there is a specimen of *C. fusipes* collected by Berkeley in which the sporophores arise from a thin, brownish black strand.

Thus it is apparent that the black body, from which the sporophores of *C. fusipes* take their origin, was familiar to the older mycologists. Yet it seems that this mycelial structure, the nature of which has given rise to such varied interpretations as those of sclerotium, persistent stipe, mycelial cordon and perennial pseudorhiza, lacks simple anatomical description and illustration.

II. Source of material

This work was begun with the collection of sporophores of *C. fusipes* growing on a stump at Leigh Woods, Bristol, in August 1934. The fact that the sporophores were obviously arising from a black, sclerotium-like body attached to the stump, in which black lines were evident, particularly engaged my attention. In the two following years, numerous collections were made of the fungus, principally in France. In July and August 1935, specimens of *C. fusipes* were found on oak trees and stumps and on beech trees in the forests of Marly, St Germain and Rambouillet near Paris. In July 1936, further collections were made from Marly forest, chiefly from an almost pure oak stand near Fourqueux. Here, *C. fusipes* was particularly common and, altogether, collections were made from twenty-seven mature and apparently healthy oaks, on which the fungus was growing in such a manner as to suggest that it was parasitic to some degree. Usually, the clusters of mushrooms were found on the large roots at soil level or just below the surface but a number of specimens were collected from the trunk at soil level and at as much as a foot above the soil. The sporophores arising from the roots were generally within a few feet of the trunk and I never found them more than eight feet distant from the base. They were always directly attached to the trunk and indirectly or, nearly always, directly attached to the root; thus, instances where a black body was interpolated between sporophore and root were in the minority.

On the roots of one oak tree, sporophores of *C. fusipes* var. *oedema-*

topus (Schaeff.) Fr. were found. This variety is readily distinguished by the pulverulent pileus and the very ventricose, pulverulent stipe. In Pl. XIV, fig. 1, two sporophores are shown arising from a piece of infected root, in which a superficial black plate and black lines are evident. After a close study of the material available, it becomes evident that, so far as the mycelium and its effect on the host is concerned, the variety is in no way different from the type. The black lines and ovals and even the black bodies from which the sporophores arise are all identical with those associated with typical *C. fusipes*.

III. Development of the fungus in pure culture

Both multispore and monospore isolations of *C. fusipes* have been grown and studied upon a variety of artificial media. Mycelial growth is slow, requiring about a month to form a colony 1 in. in diameter upon 2 % malt extract agar. The first hyphae to appear are hyaline and granular with an average diameter of $1{\cdot}7\,\mu$. About a week later, dark brown hyphae $2{\cdot}5$–$3\,\mu$ in diameter appear in the cultures. These hyphae are less granular and have large drops of opaque brown substance firmly attached to the walls.

A feature of the cultures is the production of black mycelial plates which extend through the medium to make contact with the glass wall of the culture vessel and frequently by their growth isolate large cylinders of medium. The stages in the formation of the mycelial plate are essentially the same as those already described for *Polyporus squamosus* (Campbell & Munson, 1936). The plates are also formed between averting mycelia of both monospore and multispore origin in a manner similar to that occurring in *C. radicata* (Campbell, 1938).

A number of cultures were set up from spores and mycelium of *C. fusipes* on sterilized blocks, cut from roots and branches of oak, beech and horse chestnut, to demonstrate the formation of the black plates in pure culture. The test-pieces, which were about $\frac{1}{2}$–$\frac{3}{4}$ in. thick, some with bark intact and others stripped, were placed on a wad of cotton-wool, soaked in water, in wide boiling tubes. Mycelial growth was very slow, about three months being required to cover the test-piece with the brown mycelium of the fungus. Brownish black plates were found in all the test-pieces when the cultures were opened at periods from three to eighteen months after inoculation. Extensive brown-black plates were seen on the surface of the wood as well as narrow black lines which represent a section of similar plates formed more deeply in the wood. Microscopic examination of the plates formed in the test-pieces showed that they were identical in structure with the black plates found in naturally infected roots.

IV. The structure of the black plate

The development of the black plate in the inoculated wood-blocks was followed from sections, about 5 μ thick, cut on a freezing microtome. A transverse section of the test-piece shows the cork cells and tracheides within the black line filled by tightly packed, brown hyphae of diameter varying from 3 to 15 μ. A longitudinal tangential section of the wood through a black plate is shown in Pl. XIV, fig. 5. Here, the stages in the compacting of the hyphae, which results in the black plate, can be followed, while the individual hyphae forming the plectenchyma are still largely recognizable as such. The smaller hyphae distinguishable in the tracheides are from 2·5 to 5 μ in diameter, with clamp connexions and septa. They produce numerous, closely placed branches which, ramifying in the confined space of the tracheide, form a dense prosenchyma without interhyphal spaces. The intertwining of the hyphae, together with the formation of numerous swollen branches, results in what, in section, appears to be a difficult jig-saw puzzle, so numerous and irregular are the indentations and peg-like growths. Measurement of individual cells is unreliable, because of the arrangement of the hyphae, but it is clear that many of the cell cavities are 20–25 μ in diameter. The walls of all hyphae within the black plate are deeply stained by the brown pigment, considerable amounts of which are to be found on the tracheide walls and in the connecting pits. Although these hyphae of the black plate have apparently a similar function to those of *Armillaria mellea* (Campbell, 1934), they differ greatly in appearance. The bladder-hyphae of *Armillaria* are much larger, isodiametric and of fairly constant average size, the black plate formed of them appearing in section, pseudoparenchymatous in contrast to the prosenchymatous structure of the black plate of *Collybia fusipes*.

V. The pseudosclerotium

The most obvious sign of the existence of the fungus in the roots, from which the sporophores of *C. fusipes* arise, is a number of prominent, rather thick black lines. These are sections of plates or sheets composed of swollen, pigmented hyphae and often appear as circles or ovals. Dissection of a black plate reveals that it forms the bounding-layer of a roughly spherical or ovoid body buried in the tissues of the root. Typically such bodies ultimately fuse with the extensive crust-like body on the surface of the root. This superficial body is a constant feature of roots which are producing large numbers of sporophores. Its outer black covering has been noted by Buller (1934) who reported that the thin black crust on the root was continuous with the black outer covering of the "stroma-like" fungal strand to which the fruit bodies were attached. This crust (Pl. XIV, figs. 1, 2)

is composed of brown hyphae identical with those forming the black line in the wood. Below it are rows of cork cells, forming the cork film, which are frequently interrupted by masses of hyaline hyphae. As a result, this area appears whitish to the naked eye. Immediately below the white zone is another black line which is continuous with the black crust on the surface of the root and thus forms a thin, sheath-like superficial body, composed of a bounding layer, or rind, of swollen, brown hyphae and a pith of the cork cells of the root interspersed with irregular masses of hyaline mycelium. The whole appearance recalls the flattened *Rhizomorpha subcorticalis* of *Armillaria mellea* as found between the bark and wood of an infected tree. It differs, however, in its superficial position and in the fact that the black body is not resolved into the network of anastomosing rhizomorphs, which is such a constant character of *Armillaria*. Extensions of the superficial body are indicated by the deeply formed, black plates in the root. Usually the connexion between these plates and the bounding layer of the superficial body can be readily traced.

From the flattened body on the surface of the root, sporophores frequently arise directly without the intervention of any kind of mycelial strand, but, at times, black bodies of varying size and shape are interpolated between the sporophores and the superficial body. These bodies appear to be of two types. The first, shown in Pl. XIV, fig. 2, is a peg-like outgrowth of varying length, usually 2–3 in., which ends in a large bushy head. Sporophores generally arise from the head but they may develop from the stalk portion. The bushy appearance of the head is due to a large number of persistent stipe-bases, which are seldom more than $\frac{1}{2}$ in. long and $\frac{1}{10}$ in. in diameter. These parts of the stipe-base are, in this type of body at least, dried and much twisted until they appear as little more than bristles. They apparently represent the remains of that portion of the stipe which is blackish in the freshly collected sporophore. Generally the stalk portion of such a body seems to have been formed by the lateral fusion of two or more larger stipe-bases. The second type of body is a more amorphous structure. It is generally very short and thick, being derived from the fusion of a number of stipe-bases which have been greatly enlarged after the rest of the sporophore has disintegrated. The body shown in Pl. XIV, figs. 3, 4, is the result of a number of such fusions. It appears to be the kind which Fayod (1889) described as a thick mycelial cordon, composed of fused stipe-bases. It also resembles to some extent the upper portion of Buller's (1934) drawing (Fig. 195) of a "perennial pseudorhiza", except that my specimen was short, and attached directly to the black crust without the intervention of the long, tapering "pseudorhiza" in that drawing. Frequently, this type appears as a rough, spherical mass with an irregular surface representing, perhaps, the type illustrated by Bulliard (1784) in his Plate 106. But, it was never possible to determine with cer-

tainty the age of any particular part or the stages in the development such as have been figured diagrammatically by Buller in his Fig. 194 or as shown in his drawing of the "perennial pseudorhiza" in his Fig. 195. Nothing similar to this succession of persistent stipe-bases has been seen; the only ones to which a definite age could be ascribed were those of the current year.

Although much has been written about the black bodies, nothing seems to be known of their anatomical structure. Examination of a large number has shown that all have a similar structure, consisting of a black or dark brown rind, formed of brown, closely compacted hyphae of large diameter, and a cortex and medulla composed of thin, hyaline hyphae. The thickness of the rind is variable; it is usually about 20 μ but may attain a width of as much as 100 μ in the older bodies. The hyphae of the rind are identical in size and arrangement with those forming the black plates in both naturally and artificially infected roots. Below the rind is a cortex of tightly interwoven hyaline hyphae, 2 μ in diameter, and finally a medulla composed of similar hyphae arranged parallel to the longitudinal axis of the body. The medulla is sometimes clearly distinguishable from the cortex but medulla and cortex may merge so imperceptibly that no definite limits can be ascribed to either. Altogether, the structure closely resembles that of a typical sclerotium. Another similarity is the property of healing wounds; sections through the older bodies show that they are able to cut off damaged tissues by the formation of a new rind below the wound in a manner strictly comparable to that of a true sclerotium.

As has been pointed out, the black rind of a body, formed from fused stipe-bases, is continuous with the black crust of the superficial body buried in the tissues of the root. Thus, the sclerotium-like, black body is simply an extension of the body immersed in the root; the whole being surrounded by a definite rind which converts it into a morphological entity, the pseudosclerotium, on the criteria previously advanced for *Armillaria mellea* (Campbell, 1934). This external prolongation of the pseudosclerotium serves in the translocation and storage of food materials, thus making possible a more economical production of sporophores at points near the surface of the soil.

Summary

The sporophores of *Collybia fusipes* have been found attached to the trunks and roots of oak and beech trees. Black lines were always evident in the tissues of the host. Sporophores have been found arising from black bodies of variable shape which were in turn attached to the tree roots. Such bodies have been variously described as (1) a sclerotium, (2) the stalk of the previous year's mushroom, (3) a

Fig. 1

Fig. 2

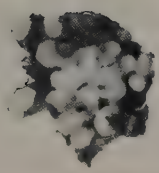

Fig. 3

Fig. 4

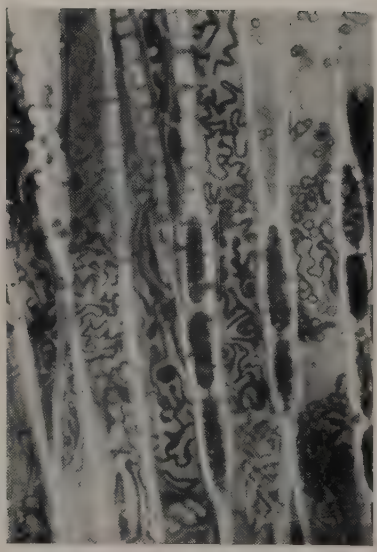

Fig. 5

mycelial strand formed by the fusion of stipe-bases from sporophores of previous years and (4) as a "perennial pseudorhiza" similarly composed.

The growth of the fungus was followed in pure culture on a variety of media from both monospore and multispore isolations. On both artificial media and wood blocks, black plates or lines, as they appear in section, similar to those occurring in nature have been formed.

These black plates are composed of a dense prosenchyma of dark brown, swollen hyphae, similar to those forming the rind of a typical sclerotium. From a consideration of the structure and development of these plates, the suggestion is made that they form the limiting layer of sclerotium-like bodies in the host, which are distinguished as pseudosclerotia.

Evidence is given to show that the black bodies, from which the sporophores arise, are formed by the amalgamation of numbers of persistent stipe-bases which become much enlarged and develop a thick black rind. Since this rind is continuous with the black plates in the host-tissues, the bodies are described as extensions of the pseudosclerotia immersed in the host.

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EXPLANATION OF PLATE XIV

Fig. 1. Sporophores of *Collybia fusipes* var. *oedematopus* (Schaeff.) Fr. arising from the superficial black plate on an infected oak root. × 4/5.

Fig. 2. Black body attached to a piece of oak root. The under side is exposed to show the lower black plate of the superficial body. × 4/5.

Fig. 3. View from above of an irregular black body composed of swollen stipe-bases. The white medulla has been exposed by cutting across the top of the structure. × 4/5.

Fig. 4. Longitudinal section of the body shown in fig. 3. The gradual envelopment of the swollen stipe-bases into the general tissue of the body can be followed. × 4/5.

Fig. 5. Longitudinal tangential section inoculated horse chestnut root showing the mycelium composing the black plate. Note particularly the irregular shapes of the hyphae and the peg-like indentations formed by the branches. Unstained. × 160.

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SOME NEW SPECIES OF MOULD FUNGI

By GEORGE SMITH

Department of Biochemistry, London School of Hygiene and Tropical Medicine, University of London

(With Plates XV and XVI)

Mucor sexualis n.sp. (Cat. No. 39), Pl. XV, figs. 1–5

In 1922 Mrs M. N. Kidd, of the Botany School, Cambridge, isolated from a rotting strawberry a homothallic species of *Mucor*, believed at the time to be a *Rhizopus*. In 1931 a culture, obtained from Cambridge by courtesy of Prof. F. T. Brooks, was brought by the late Mr J. H. V. Charles to the London School of Hygiene and Tropical Medicine. The fungus has never been identified; it differs substantially from all previously described species of the genus.

The most striking characteristic of the mould is its abundant production of zygospores. On Czapek agar very little aerial mycelium is formed, almost the whole of the visible growth consisting of short hyphae bearing zygospores. On this medium sporangia are produced very sparsely or not at all, and, since all efforts to obtain germination of zygospores have failed, this has meant that attempts to obtain subcultures from colonies on Czapek agar have mostly been unsuccessful. On wort agar or vegetable extract agars aerial mycelium is more abundant and there is regular, though very sparse, production of sporangia. Cultures remain viable for about five months. Successful transfers have only occasionally been obtained from cultures aged six months or more.

Diagnosis

Mucor sexualis sp.nov. Herba breve, altitudine non amplius quam 2 mm.; sporangiophoris raris, non ramosis, rectis, brunneolis in cultis senibus, 0·5–1·4 mm. long., 7·5–8·5 μ diam.; sporangiis nigris, globosis leviter applanatis, membrana diffluente, 40–85 μ diam.; columellis subglobosis vel piriformibus, sine collarillo, 30–37 μ diam.; sporidiis versiformibus—subglobosis, ovatis, polygoniis, reniformibus—8–18 μ long.; zygosporis ex hyphis bifurcis, nigris, verrucosis, 60–180 μ diam.

Habitat in frago putrescente, Cantabrigiae, Anglia.

Growth not exceeding about 2 mm. in height; sporangiophores straight, unbranched, slightly brown with age, 0·5–1·4 mm. long and

7·5–8·5 μ in diam.; sporangia black, somewhat flattened globose, 40–85 μ in diam. with sporangial wall thin and diffluent; columellae sub-globose or somewhat pyriform, without collarette, 30–37 μ in diam.; spores very irregular in shape and size, subspherical, ovate, polygonal, reniform, etc., 8–18 μ in long axis; zygospores formed from bifurcated hyphae, their development proceeding almost exactly symmetrically, the ripe spores being black, verrucose, 60–180 μ in diam., with large equal suspensors. No true rhizoids are formed, the sporangiophores arising from any point on the aerial hyphae, and stolons are completely absent.

Penicillium carneo-lutescens n.sp. (Cat. No. 146), Pl. XVI, fig. 6

The fungus was isolated in October 1937 from a sample of dried Kentish hops which had been plated out on wort-agar in order to detect the presence of latent mould infection. One Petri dish contained, amongst a variety of other species, a single colony of what appeared to be a typical strain of *Aspergillus terreus* Thom (this species, at least in most freshly isolated strains, forming colonies with a highly characteristic appearance, the surface being slightly mealy, almost velvety, and pale sandy brown). Microscopical examination of the colony *in situ* showed, however, clusters of typical penicilli, instead of the columnar heads of *A. terreus*, the slight mealy appearance of the colony being due to well-marked fasciculation of the conidiophores.

Very few species of *Penicillium* show conidial colours other than shades of green during the growing period, and still fewer exhibit buff, fulvous or brownish tones. *P. ochraceum* (Bainier) Thom is quite distinct in colour, being darker and duller than the new species and fairly described as greenish brown; it belongs to Thom's group "Lanata-Typica" (Thom, 1930). *P. avellaneum* Thom & Turesson is in the group "Biverticillata-Symmetrica" and is ascosporic. *P. capreolinum* Biourge is also biverticillate and, like several other species in the group, fruits very tardily and sparsely in culture. None of these species forms fasciculate colonies and all differ morphologically from *P. carneo-lutescens*, which obviously belongs in the group "Fasciculata" and is, apart from colour, very similar to *P. cyclopium* Westling.

Diagnosis

Penicillium carneo-lutescens sp.nov. Coloniis late crescentibus, carneo-lutescentibus, paulo granosis paene velutinis, marginibus albis 1·5 mm. crassis; reverso fulveolo, subzonato in cultis senibus; guttulis plurimis, magnis, incoloratis dein brunneolis; conidiophoris fasciculatis, scabris, 150–300 μ long. et 3·8–4 μ diam.; penicillis asymmetricis, compactis, plerumque cum axe principale et uno duobusve ramis ex nodo primo; ramis 18–22 μ long.; metulis 12–15 (19) × 3–4 μ, cum apicibus paulo

inflatis; sterigmatibus 9–10 × 2·2–2·5 μ; conidiis glabris, globosis aut subglobosis, 3–3·5 μ diam., in catenis parallelis vel subdiversis; odore mediocre, mucido.

Fungus in flore *Humuli lupi* inventus, Cantio, Anglia; non parasiticus.

Grows well on all common culture media; colonies spreading, pale sandy brown, very close to "pinkish-buff" (Ridgway, xxix), with white margin about 1·5 mm. broad during the growing period; surface appearing almost velvety but showing distinct mealiness at edges and seen to be definitely fasciculate when examined under a low power of the microscope; reverse at first pale buff becoming darker from centre outwards, indistinctly zoned in old cultures; drops numerous, large, at first colourless then pale brown; conidiophores arising mostly from submerged hyphae, distinctly roughened, 150–300 × 3·8–4 μ; penicilli asymmetric, usually with main axis and one or two parallel branches from first node, each bearing compact clusters of metulae and sterigmata; branches 18–22 μ long; metulae 12–15 μ (occasionally up to 19) × 3–4 μ, slightly swollen at tip; sterigmata bluntly pointed, 9–10 × 2·2–2·5 μ; conidia smooth, globose or nearly so, 3–3·5 μ in diam., borne in chains which are roughly parallel at first, then more or less divergent; odour moderately strong, mouldy.

Penicillium pusillum n.sp. (Cat. No. 147), Pl. XVI, figs. 7, 8

During an examination of some samples of dried blue peas, Dr G. E. Turfitt, working in this Department, found that the principal mould infection was due to a monoverticillate species of *Penicillium* characterized by its very restricted growth and by a curious dark dull purple reverse of colonies on Czapek agar. When cultivated on wort agar, growth was somewhat more rapid and, after a few days, masses of sclerotia appeared. The mould was therefore compared with those monoverticillate Penicillia which are known to form sclerotia. Of these *P. Thomii* Maire, *P. Mangini* Duché & Heim and *P. sclerotiorum* van Beyma are included in the collection of Penicillia kept at the London School of Hygiene and Tropical Medicine. *P. Thomii* spreads widely and rapidly, with the reverse of colonies colourless to yellow and with pinkish sclerotia. *P. Mangini* is closely related to *P. Thomii* and forms yellow mycelium with brown sclerotia and the reverse is yellow to orange. *P. sclerotiorum* grows exceedingly rapidly on all media, with masses of brilliant red sclerotia. A number of other species have been described by Sopp (1912) but his diagnoses are quite inadequate and as type cultures are not available his names are little better than *nomina nuda*. It is believed that the species isolated by Dr Turfitt is new to science.

Diagnosis

Penicillium pusillum sp.nov. Coloniis in agaro Czapekii lentissime crescentibus, restrictis, primo caesiis deinde cum mycelio aerio albo aut vinaceo, paulo funiculosis, rugosis; reverso brunneo-purpureo cum agaro paulo concolorato; guttulis incoloratis; glomeres mycelii sed nulla sclerotia efficientibus; coloniis in musto ex hordeo cum agaro celerius crescentibus, albis glaucisque, paulo floccosis et funiculosis, rugosis, mox sclerotia brunneola numerosa efficientibus; conidiophoris ex hyphis repentibus vel funiculis hyphorum, plerumque non ramosis raro cum uno ramo, glabris, cum apicibus paulo inflatis, 35–55 μ long. et 1·5–2 μ diam.; penicillis monoverticillatis; sterigmatibus paene cylindricis, 10–11 (15) × 1·8–2 μ, aliquando longioribus et septatis; conidiis glabris, primo ovatis deinde globosis 2–2·5 μ diam. aut subglobosis 2·3–2·8 × 2–2·2 μ; sclerotiis brunneolis, irreguliter globosis, ferme 300 μ diam., confluentibus.

Habitat in seminibus exsiccatis *Pisi sativi*.

Colonies on Czapek agar growing very slowly and restrictedly, attaining a diameter of about 1 cm. in 12 days and thereafter spreading very little, pale bluish grey, gradually becoming overgrown with white to vinaceous mycelium, thin and tough, with surface growth consisting of trailing hyphae and ropes of hyphae, usually with centre depressed or folded and wrinkled; reverse dark dull purple becoming very deep brownish purple, with colour diffusing slightly into medium; drops colourless; dense masses of compacted mycelium formed but no true sclerotia; colonies on wort agar growing somewhat more rapidly than on Czapek agar, at first white, with patches of greyish green, slightly floccose and funiculose, wrinkled and buckled, after a few days developing masses of pale buff to pinkish brown sclerotia; reverse brownish; conidiophores arising from trailing hyphae and ropes of hyphae, mostly simple but with an occasional branch, 35–55 × 1·5–2 μ, smooth, slightly swollen at apex; penicilli mostly strictly monoverticillate but occasionally, especially on Czapek agar, with one or two sterigmata proliferating and developing single cross-septa (i.e. with occasional metulae mixed with sterigmata); sterigmata almost cylindrical, 10–11 (15) × 1·8–2 μ; conidia smooth, ovate at first, becoming globose to sub-globose, 2–2·5 μ diam., or 2·3–2·8 × 2–2·2 μ; sclerotia brownish, irregularly globose, averaging 300 μ in diameter, mostly confluent, composed of masses of irregularly globose or polygonal cells.

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EXPLANATION OF PLATES XV AND XVI

Figs. 1–4 are from photographs of portions of a living culture on Czapek agar in a Petri dish. Figs. 5–8 are from photographs of specimens mounted in lacto-phenol.

Plate XV

Figs. 1–4. *Mucor sexualis*. Stages in zygospore formation. × 100.
Fig. 5. *M. sexualis*. Sporangium. × 100.

Plate XVI

Fig. 6. *Penicillium carneo-lutescens*. Penicilli. × 500.
Fig. 7. *P. pusillum*. Penicilli. × 500. It is exceedingly difficult to obtain satisfactory slides of this species.
Fig. 8. *P. pusillum*. Sclerotial masses. × 25.

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Fig. 1

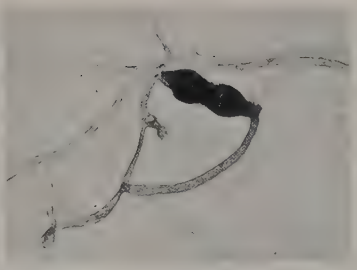

Fig. 2

Fig. 3

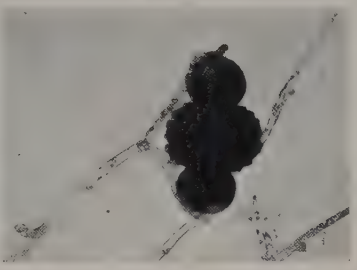

Fig. 4

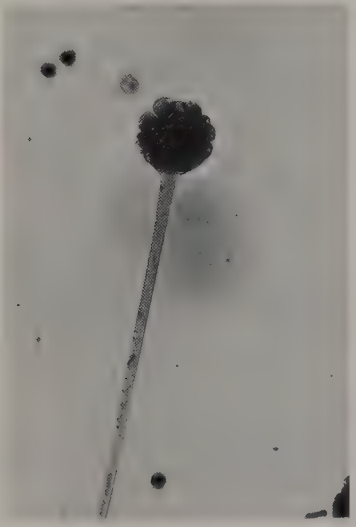

Fig. 5

Fig. 6

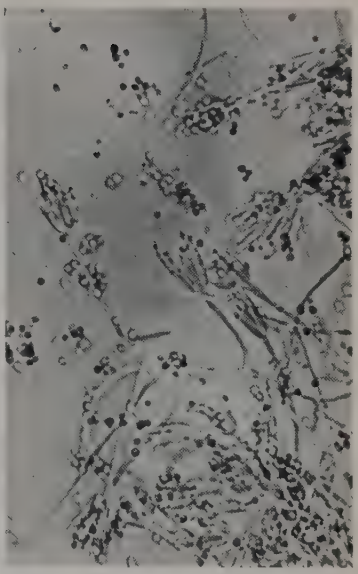

Fig. 7

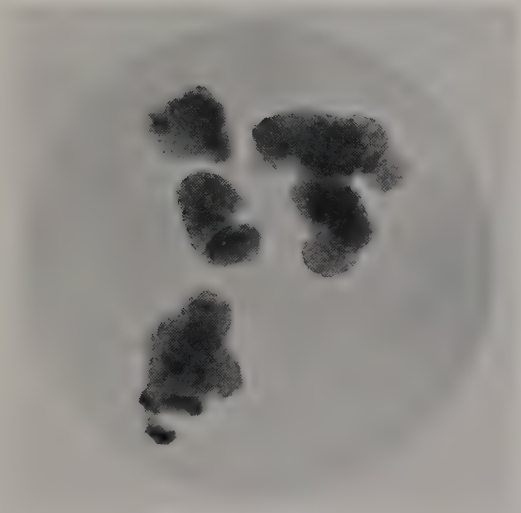

Fig. 8

GLIOCLADIUM

By T. PETCH

(With 2 Text-figures)

The genus *Gliocladium* was established by Corda in *Icones Fungorum*, IV (1840), 30, with the single species, *G. penicillioides*, which had an erect, septate stalk, branched penicillately above, the branches and branchlets septate and crowned above by a gelatinous mass containing conidia. The conidia were acrogenous, continuous, with a mucous coat. From Corda's description and figures, the fungus is white, and occurs in small tufts of fifteen to twenty erect conidiophores; the main stem of the conidiophore is stout, septate, and verrucose; the primary branches are opposite and curve upwards parallel to the main stem, and the secondary branches are similar; the ultimate branchlets, or phialides are verticillate, forming a whorl of four (or, in other words, a cluster of five) at the apex of each secondary branch. As all the branches and phialides are directed vertically upwards, and the phialides attain approximately the same height, the whole forms a candelabrum-like structure. The conidia are borne apically on the phialides, and all from one conidiophore, sometimes with those from adjacent conidiophores also, collect in a globular mass, supported by the phialides. Corda gave the height of the conidiophore as 200–250 μ, and the length of the conidium as 5·6 μ. He found the fungus on *Stereum hirsutum* and *S. sanguinolentum*.

Nothing further was heard of Corda's fungus until Winter claimed that he had obtained it in 1873 on goose dung in his culture chambers, followed by *Eurotium insigne*. It occurred in profusion up to the beginning of the development of the perithecia, and though Winter was unable to germinate the ascospores, he considered that *Gliocladium penicillioides* was the conidial stage of *Eurotium insigne*. He did not re-describe the *Gliocladium*, and I have not been able to detect it on the specimens of *Eurotium insigne* in Herb. Kew. and Herb. British Museum, which he issued in Rabenhorst, *Fungi Europaei*, no. 1732.

Schröter, in *Krypt. Flora von Schlesien*, III, 2 (1893), 220, accepted Winter's determination, and recorded *Gliocladium penicillioides* with *Eurotium insigne* on goose and dog's dung. He stated that the *Gliocladium* formed widely spread, snow-white patches, and that the branching of the conidiophore resembled that of a *Penicillium*, but was more regular. The conidia were oblong-ellipsoid, rather strongly attenuated at the ends, in long chains, but he did not give their dimensions.

Matruchot, in *Rev. Gen. Bot.* VII (1895), 321–331, stated that he had found *Gliocladium penicillioides* twice, once on a decaying agaric, and again on horse dung kept under a bell glass. In the first instance, the fungus was white, slightly pink, in the second, distinctly pink. The conidia were oval, 5–10 × 2–3 μ. He obtained *Eurotium insigne* from cultures of the conidia, but did not record which of the two collections was the source of the spores used.

Marchal, in *Bull. Soc. Roy. Bot. Belge*, XXXIV (1895), 135, described a new species, *Gliocladium macropodinum*, found on dung of Kangaroo (*Macropus*) in Belgium. It was white, with conidiophores up to 400 μ high, and narrow oval conidia, 9–11 × 2–2·5 μ, attenuated to one end. He stated that it was near *G. penicillioides*, but had a different conidiophore, and conidia twice as long.

Massee and Salmon, in their *Researches on Coprophilous Fungi*, published in *Ann. Bot.* XV (1901), stated (p. 319) "*Eurotium insigne*, originally discovered on dung by Winter in Germany, has been met with in great abundance on kangaroo, horse, and fowl dung at Kew. Its very large, globose, spinulose spores germinated vigorously in a decoction of dung, soon forming a wefted mycelium which on the fifth day produced the conidial condition of the fungus—a member of the form genus *Gliocladium*—and on the eleventh day the young ascigerous condition appeared, reaching maturity in five more days." In their systematic list, under *Eurotium insigne*, they discussed the records detailed above, and, accepting them as correct, gave the conidial stage as *Gliocladium penicillioides*, with *G. macropodinum* as a synonym. But it is, I think, clear, from recent examples of *G. penicillioides* on *Stereum*, and from Corda's, Matruchot's and Marchal's figures and descriptions, that these two are distinct species, and that it is *G. macropodinum* which is the conidial stage of, or occurs with, *Eurotium insigne*.

Tulasne, in *Sel. Fung. Carp.* III (1865), 64, described *Hypomyces aureo-nitens* on *Merulius tremellosus* Pers., and stated that it was accompanied by a conidial fungus, the conidiophores of which had a main stem, 100–200 μ high, 6–8 μ diameter, branched above, with catenulate, linear ovate, continuous, hyaline conidia, 4–5 × 2·5 μ. Plowright, in preparing his *Monograph of the British Hypomyces* (1882), found the same conidial fungus in company with *Hypomyces aureo-nitens* on *Stereum* and drew a figure of it. His figure undoubtedly represents a *Gliocladium*, with the usual confused mass of conidia seated on the apices of the phialides, and examination of his specimen shows that it agrees with *G. penicillioides*. But Cooke, in reproducing the figures in *Grevillea*, altered the conidial stage completely, and drew a fan-shaped *Penicillium*, with divergent chains of conidia. Consequently, Saccardo described this conidial stage from the figure as *P. socium* in *Syll. Fung.* II, 468, and again as *P. hypomycetis* in *Syll. Fung.* IV, 80,

changing the latter name to *Gliocladium hypomycetis* in *Ann. Mycol.* VII (1909), 434. As far as these names relate to anything real, they are synonyms of *G. penicillioides*, but Cooke's figure is imaginary. *Hypomyces aureo-nitens* has been collected again at Buckden, Yorks., September 1936, and Keld, Yorks., October 1936, in both instances on *Stereum* and accompanied by *Gliocladium penicillioides*. It would appear probable, therefore, that the latter is the conidial stage of *Hypomyces aureo-nitens*.

Grove recorded *Gliocladium penicillioides* for England on *Stereum* in *J. Bot.* XXIII (1885), 165, and noted that he did not observe on his specimens the gelatinous coat of the conidium figured by Corda, and that Plowright had informed him that he did not observe it on the conidial form which accompanies *Hypomyces aureo-nitens*. Corda stated that the gelatinous coat was as thick as the spore. That the conidia have a mucous coat is evident from the fact that they adhere in a globule of mucus as in *Cephalosporium*, but, as in the latter genus, the coat is not evident on isolated conidia in any of the specimens I have examined.

von Höhnel discussed various species of *Gliocladium* in a paper in *Zbl. Bakt.* II, LX (1923), 1–26, published after his death, and therefore may not represent what might have been his ultimate conclusions. He pointed out that *Verticillium Aspergillus* B. & Br. was a *Gliocladium*, which he named *G. Aspergillus* (B. & Br.) v. Höhn., and that Tulasne and Plowright had described what was probably the same species as the conidial stage of *Hypomyces aureo-nitens*. Examination of the type of *Verticillium Aspergillus* B. & Br., on *Poria vaporaria*, confirms von Höhnel's suggestion. The fungus has a verrucose main stem, up to 9 μ diameter, parallel phialides, and oblong-oval or cylindrical conidia, 2–4 × 1–1·5 μ. It is *Gliocladium penicillioides*. It seems strange that von Höhnel did not refer *Verticillium Aspergillus* to the latter species, but the explanation appears to be that he had followed Winter, Schröter and Matruchot in regarding the conidial stage of *Eurotium insigne* as *Gliocladium penicillioides*.

Grove, in *J. Bot.* XXIV (1886), 199, described *G. lignicolum* as a doubtfully new species, differing from *G. penicillioides* only in its smaller conidia and in growing on wood. It had been collected twice, and in one instance the hyphae and branchlets were tinged brown. The dimensions of the conidia were 2–2·5 × 1·5 μ, figures which fall within the range of *G. penicillioides*. von Höhnel gave the conidia of a specimen (*G. Aspergillus*) on *Polystictus versicolor* as 2–3 × 0·5–1 μ. As regards the host, there is the possibility that the wood might have contained the mycelium of a polyporoid fungus.

In *Ann. Roy. Bot. Gard. Peradeniya*, X (1926), 137, I described *Gliocladium microsporum* on *Polystictus flabelliformis*, from Ceylon. The fungus occurred in small, scattered, white tufts as in *Gliocladium penicillioides*, and is similar to this in structure and appearance, but

the primary branches, in the specimens examined, bear the phialides at their apices, secondary branches being lacking. The conidia are oblong-oval, 1·5–3 × 0·75–1 μ, or subglobose, 1 μ diameter. On further consideration it would appear preferable to regard this as a form of *G. penicillioides*.

G. penicillioides occurs in small, scattered, white tufts, about 200 μ high, each consisting of a small number of conidiophores. The individual conidiophores are separate below, but may be bound together above by the mass of conidia. The main stem is stout, 6–9 μ diameter, septate, minutely verrucose, simple below, with lateral branches in the upper half or third, expanded at the points of origin of the branches. The primary branches are usually opposite, but sometimes the lowest branch is solitary; they are stout and cylindrical, usually about 20 μ long, and curve upwards parallel to the main stem. Each bears secondary branches of the same shape, usually about 10 μ long, in whorls of two to four, and each of the latter is crowned by a cluster of three to five, narrow flask-shaped, or narrow-conoid, phialides of about the same length, all erect, parallel and crowded. The conidia are oval or subcylindrical, ends obtuse, hyaline, usually 2–5 × 1·5–2 μ, produced singly, not in chains, and collected in an apical globule supported by all the phialides. It occurs on Thelephoraceae and Polyporaceae, and is most probably the conidial stage of *Hypomyces aureo-nitens*. Its synonymy, as far as ascertained at present, is

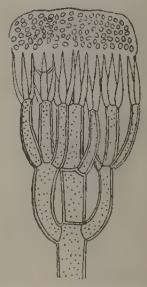

Fig. 1. *Gliocladium penicillioides* (after Corda).

Gliocladium penicillioides Cda., *Icon. Fung.* IV (1840), 31; *Verticillium Aspergillus* B. & Br., *Notices of British Fungi*, no. 1384 (1873); *Penicillium socium* Sacc., *Syll. Fung.* II (1883), 468; *Penicillium hypomycetis* Sacc., *Syll. Fung.* IV (1886), 80; *Gliocladium hypomycetis* Sacc. in *Ann. Mycol.* VII (1909), 434; *Gliocladium lignicolum* Grove in *J. Bot.* XXIV (1886), 199; *Gliocladium Aspergillus* (B. & Br.) von Höhnel in *Zbl. Bakt.* Abt. II, Bd. LX (1923), 21; *Gliocladium microsporum* Petch in *Ann. Roy. Bot. Gard. Peradeniya*, X (1926), 137.

For some years, I have been recording as *Gliocladium penicillioides* a species of *Gliocladium* which occurs on Myxomycetes and has been found in various parts of the country on *Physarum*, *Didymium*, *Dictydium* and *Stemonitis*. It forms a more or less continuous, white crust, about 0·1 mm. thick, over the sporangium. The conidiophores are crowded, with a main stem about 3 μ diameter, with lateral branches which begin at the first septum, about 20 μ from the base, the branches being opposite, or in whorls of three, and divergent. These branches again branch similarly, the branches of adjacent conidiophores interlacing. The phialides are subulate, about 18 × 1 μ, in a final cluster of three

or five, parallel or divergent. The stem and branches are minutely verrucose, and expanded at the nodes. The conidia are oval or oblong-oval, hyaline, 2·5–4 × 1·5 μ. This species differs from *Gliocladium penicillioides* in its divergent and more luxuriant branching. It is probably the species described by Preuss as *Penicillium album* from specimens on *Dictydium*, and I propose to name it *Gliocladium album* (Preuss) Petch.

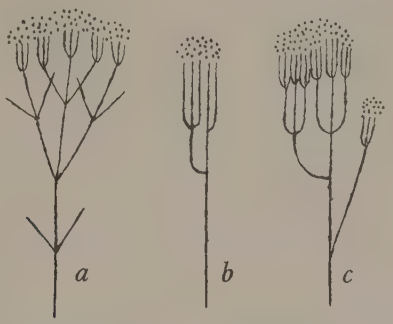

Fig. 2. Conidiophores of *Gliocladium* (diagrammatic). *a*, *G. album*; *b*, *G. strictum*; *c*, *G. caespitosum*.

Eichelbaum, in *Verh. Naturw. Ver. Hamburg*, ser. 3, XIV (1906), 37, described *Gliocladium africanum*, found at Amani on rotten wood in company with *Physarum nutans*. It was not said to occur on the *Physarum*. The conidiophores were described as solitary, not in tufts, pale brown under a lens, but pale yellow by transmitted light. The conidia were oval, 4 × 2 μ. From the description it would appear that this is not *Gliocladium album*. In the available specimens of the latter, the fungus occurs only on the sporangia of the Myxomycetes.

The conidial stage of *Hypomyces Broomeanus*, which is parasitic on *Fomes annosus*, is a *Gliocladium*. The conidiophores are crowded in a continuous sheet, white in mass, about 100 μ high, with a stout stem, 4 μ diameter below, sparingly branched. The lower branches are usually solitary and distant, while the upper branches (phialides) are solitary, or opposite, or in whorls of three. The latter are about 30 μ long, tapering, and all branches are parallel to the main stem. The conidia are hyaline, oblong-oval or narrow-oval, slightly inequilateral, ends obtuse, 5–11 × 2–2·5 μ, the longer ultimately becoming one-septate or pseudo-septate, united by mucus in heads about 14 μ diameter and ultimately in large masses. I have described this species as *Gliocladium strictum* in *British Hypocreales*.

Cooke, in Plowright's *Monograph of the British Hypomyces*, figured an alleged conidial stage of *Hypomyces Broomeanus* as having a much-branched conidiophore with spreading branches and phialides, and

conidia in chains; and Saccardo, in *Syll. Fung.* IV, 153, described that figure as *Verticillium microspermum* Sacc. The true conidial stage of *Hypomyces Broomeanus*, however, is not in the least like Cooke's figure. Saccardo's name is merely a name for Cooke's figure, and should be discarded.

Another species of *Gliocladium* occurred on immature *Nectria mammoidea* Phill. & Plowr. on Sycamore, collected by Mr W. G. Bramley in Becca Park, Aberford, Yorks., in October 1937. The conidiophores occur in tufts, the tufts being white or yellowish and consisting of diverging conidiophores, up to 150 μ high. The conidiophore is 3–6 μ diameter below, smooth, branched above, with the lower branches solitary and the upper opposite, each branch terminating in a small cluster of conoid or narrow flask-shaped phialides, about 20 μ high, 2 μ diameter. The conidia are oblong-oval, or narrow-oval, smooth, hyaline, sometimes inequilateral, sometimes slightly curved, 5–8 × 2–3 μ. The fungus is quite different from *Gliocladium luteolum* von Höhnel (*G. piliforme* Boud., *Ic. Myc.* III, pl. 587), and it does not appear to agree with any described species. I propose for it the name *G. caespitosum*.

Gliocladium caespitosum Petch, n.sp. Conidiophoris caespites albos vel flavidos formantibus, divaricatis, ad 150 μ alt., infra 3–6 μ diam., levibus, supra ramosis, ramis inferioribus solitariis, superioribus oppositis, singulis phialides apicales paucos conoideos vel anguste ampullaceos ferentibus; phialidibus ca. 20 μ alt., 2 μ diam.; conidiis hyalinis, oblongo-ovalibus vel anguste ovalibus, interdum in aequilateralibus, interdum leniter curvulis, levibus, 5–8 × 2–3 μ. In *Nectria mammoidea* immatura.

The conidia of *Gliocladium* are not produced in chains but singly in succession at the apex of the phialide and adhere to one another as in *Cephalosporium*. In some instances, especially in *G. album*, the conidia persist in files in the apical mass, but in that species sometimes a phialide at the margin of a tuft diverges so much from the others that its conidia do not unite with the general mass, but form a spherical globule exactly like that of a *Cephalosporium*. *Gliocladium* should be classed, not with *Penicillium*, but with *Cephalosporium* and *Acrostalagmus*. It is an *Acrostalagmus* in which the phialides are all situated at approximately the same level, so that their spore masses come in contact and fuse into one.

Gliocladium compactum Cooke & Massee was described in *Grevillea*, XVI (1887), 16, from specimens on damp paper from India. It was said to form minute, ferruginous tufts of erect crowded conidiophores, usually simple, with a wedge-shaped, pale brown head of conidia, held together by mucus, the conidia being oblong, catenulate, brownish hyaline, 5 × 3 μ. From the description, it was evidently not a *Gliocladium*. In the type in Herb. Kew., the tufts are more or

less circular, and consist of a mixture of rough or spinulose red-brown hyphae, 1·5 μ diameter, and ellipsoid, verrucose spores, pale yellow, brownish yellow in mass, 4 × 3 μ. The spores are not held together by mucus, but some are contained in oval or wedge-shaped asci, about 10 × 7 μ. The fungus appears to be a *Eurotium*, similar to *E. orientale*, with the perithecia disintegrated or collapsed. It no doubt occurred on plants in drying papers, and parts of the fungus adhered to the paper.

Gliocladium agaricinum Cooke & Massee was described in *Grevillea*, XVII (1889), 80, from specimens on cultivated mushrooms, the surface of the pileus of which was broken into scales by the action of the fungus. It was said to form hemispherical heaps, often confluent, pallid then white, at first gelatinous. The conidiophores were described as erect, branched, the ultimate branches in whorls of four, with a white, subglobose head of conidia, which were hyaline, subglobose, 5–6 μ diameter, at first glutinous. The type in Herb. Kew. bears irregular, somewhat translucent heaps of conidia, most of them subglobose, hyaline, 1·5–3 μ diameter, with a few larger, globose, 4 μ diameter, or oval, 4–5 × 3–4 μ. No conidiophores were found in these masses of spores. The same spores occur in the tissues of the mushroom, and apparently they ooze out through cracks. The fungus does not appear to be a *Gliocladium*.

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NEW AND INTERESTING PLANT DISEASES. I

By W. C. MOORE, M.A.
Plant Pathological Laboratory, Harpenden

(With Plate XVII)

Angular Leaf Spot of apple (*Phyllosticta angulata* Wenzl)

In July 1937 apple leaves bearing large numbers of very small, angular spots, about 1–2 mm. across, were received for examination at the Plant Pathological Laboratory from Mr R. G. W. Bush, of Lingfield, Surrey. The youngest spots were pale yellow-green and inconspicuous, and they could be seen best by holding the leaf up to the light. Viewed in this manner the leaves exhibited an almost mosaic-like appearance, and the very angular shape of the spots, bounded as they were by the finest veins, was clearly marked. Older spots were uniformly greyish or reddish brown, ultimately whitish grey, on the upper surface of the leaf, and a rather deep, dull brown below. They were mainly aggregated in groups, though not restricted to any particular portion of the leaf (see Pl. XVII, fig. 1), and occasionally the leaves were completely covered with them. In places the individual small spots had coalesced to form larger spots, $\frac{1}{2}$ cm. or more across.

The disease occurred at Lingfield* in a well-cultivated and regularly sprayed orchard of 50-year-old Bramley's Seedling trees, interplanted with 4-year-old Worcester Pearmain, but it was restricted to a relatively small block of trees occupying a portion of the orchard that was low lying and liable to flooding. The spots occurred on the older spur leaves of both varieties and on the earlier formed leaves of the shoots of Worcester Pearmain, but the later formed leaves were mostly clean and healthy. The disease did not spread to any appreciable extent, and although it appeared again on the same trees early in June 1938 it seems to be of no economic importance. Angular Leaf Spot, as the disease may be called, has so far been observed in only one other locality in England. In August 1937 Mr Bush, to whom I am grateful for the details regarding the occurrence of the disease, found it in a badly neglected grass orchard near East Grin-

* A brief reference to the occurrence of this disease at Lingfield has been made by Salmon & Ware (1938).

stead, Surrey, on leaves of Worcester Pearmain, Bramley's Seedling, Allington Pippin and Newton Wonder, but here again it was causing little or no damage.

Microscopical examination revealed the presence of two fungi on the spots, but neither was at all abundant and many spots were devoid of fungal fructifications. One of the fungi observed, but not identified, produced compact tufts of dark conidiophores from which small, hyaline, elliptical spores, 6–11 × 2–4 μ, were abstricted in large numbers; the other was a species of *Phyllosticta*. A few scattered pycnidia of the *Phyllosticta* were present on most of the leaves and others developed when the material was kept for several days in a moist dish. On the host the pycnidia were 90–170 μ in diameter, and in water they extruded tendrils of unicellular hyaline spores measuring 6–8 × 3–4 μ. Single spore isolations on malt agar gave a whitish grey to buff-coloured felt of mycelium with relatively abundant pycnidia, the largest of which were as much as 280 μ in diameter. The spores also tended to be rather longer and distinctly broader in culture, the average dimensions being 5–9 × 4–6 μ. Isolations made from young leaf spots on which no fungus growth was visible gave cultures identical with those obtained from single spores of the *Phyllosticta*.

Various unnamed or named species of *Phyllosticta*, including *P. Mali* Prill. & Delacr. and *P. prunicola* Sacc. have been observed from time to time in association with spotting of apple foliage in this country, but the very angular spots observed in the Surrey material are quite distinct from the round or rounded spots hitherto described, and illustrated, for instance, by Salmon (1907). On the other hand, the present disease appeared to be very similar to one observed in Austria in 1935 by Wenzl (1936), and attributed by him to a new species of *Phyllosticta* which he named *P. angulata*. Wenzl observed the disease in several varieties of apple (and also in *Crataegus azarolus* L.) in three different nurseries situated in the moister parts of Lower Austria, but in each instance it was restricted to a comparatively small part of the plantation. In view of the great similarity between the two diseases photographs of the English material and a pure culture of the *Phyllosticta*, derived from a single pycnospore, were sent to Dr Wenzl, who, after examination, considered the fungus to be identical with *P. angulata*, notwithstanding the fact that he had been unsuccessful in obtaining fructifications of the latter in pure culture. Dr Wenzl kindly sent me some leaves attacked by *P. angulata* that he had collected in September 1937, and these closely resembled the English material. Pure cultures obtained from them by isolating single pycnospores produced pycnidia on malt agar and were similar in all respects to cultures of the English fungus. The dimensions of the pycnidia and spores of *P. angulata* on the host plant agreed with

those given by Wenzl (viz. 80–130 μ (up to 150 μ) and 5·5–6·5 × 2·7–3·4 μ respectively), but in culture the range was much greater. The pycnidia measured up to 210 μ in diameter and spores 9 μ long were by no means infrequent. Careful comparison of these two very variable fungi leaves little or no doubt that the form found in England is identical with *Phyllosticta angulata* Wenzl. The constant association of this fungus with Angular Leaf Spot strongly suggests that it is the cause of the disease, but no confirmatory inoculation experiments have yet been carried out.

Leaf Blotch of *Aquilegia* (*Haplobasidium pavoninum* von Höhn.)

Early in May 1938 Mr G. W. Gibson, of the Isles of Scilly Experiment Station, sent me some diseased leaves taken from a seedling *Aquilegia* growing in a garden at St Keverne, Cornwall. The individual stalked segments of the leaves exhibited conspicuous, irregularly shaped, buff-coloured blotches, about $\frac{1}{4}$–1 in. across and, for the most part, spreading inwards from the margins (Pl. XVII, fig. 2). Some of the leaflets had been almost entirely killed and in others a well-marked purplish band, $\frac{1}{8}$ in. across, marked the boundary between the healthy and the dead or diseased parts.

At first sight the trouble was thought to be the work of a leaf miner, but no insect was present, and on closer examination a compact fungus-coating was found on the lower surface of the blotches and, to a less extent, on the upper surface. This occurred mainly in lines along the smaller leaf veins and was at first light in colour, but soon turned dark brownish grey. It consisted of the short conidiophores and conidia of *Haplobasidium pavoninum* von Höhn., a fungus previously recorded only from Austria and from Spain. The conidiophores emerged through the cuticle and were simple, smoke-grey, 24–45 μ long and 4–7 μ broad at the base, swelling above to a rounded, flattened head 11–15 μ across, on which 1–4 (mostly 3) sterigma-like cells, measuring 15–18 × 5–6 μ, were borne. The conidia were borne in short chains on the sterigma-like cells or sometimes directly on the expanded head of the conidiophore. The conidia were spherical or ellipsoidal, hyaline at first, then greyish brown, 7–11 μ long and 6–9 μ broad, with a clearly defined wall $\frac{1}{2}$ μ thick.

The genus *Haplobasidium* was founded on the species *H. Thalictri* by Eriksson (1889) who observed it on living leaves of *Thalictrum flavum* in Sweden. The only other species of the genus is *Haplobasidium pavoninum*, which was described by von Höhnel (1905) as the cause of "peacock-like" spots on the leaves of *Aquilegia vulgaris* at Altenmarkt in Styria. According to Stevenson (1926) the same fungus has also been seen in Spain.

Fig. 1

Fig. 2

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EXPLANATION OF PLATE XVII

Fig. 1. Leaves of Bramley's Seedling apple affected with Angular Leaf Spot.
Fig. 2. Leaflets of a seedling *Aquilegia* attacked by *Haplobasidium pavoninum* von Höhn.

(*Accepted for publication* 19 *July* 1938)

NOTE ON CULTURES OF *SPHAEROBOLUS STELLATUS* TODE

By FRANCES L. STEPHENS

(With 1 Text-figure)

Some time ago on giving a student potato-agar cultures of *Sphaerobolus stellatus* Tode to examine with the help of A. H. R. Buller's account of this fungus in his *Researches on Fungi*, v, 1933, she drew my attention to his statement on p. 288 that he too, like Miss L. B. Walker, had "not been able to obtain fruit-bodies on a malt-agar medium". Miss Walker in the *J. Elisha Mitchell Sci. Soc.* xlii, 1927, p. 152, writes that "cultures upon corn-meal and agar media never fruited", although she obtained an abundance of fruits on willow-wood, half-rotted horse dung, sawdust and mixtures of horse dung and sawdust.

In the mycological laboratory of the British Museum (Natural History) I have had *Spaerobolus stellatus* fruiting on potato dextrose agar since 1932 when cultures were made from material collected in Epping Forest (Essex). These have been subcultured frequently.

Another series of cultures was made in November, 1937, from material growing on rotten wood and horse dung at Limpsfield Common, Surrey. This was cultured both on potato dextrose agar and on malt agar, the media being approximately neutral. The photograph shows the large number of fruits which resulted in a few weeks' time. The fungus in culture is apparently quite normal.

Another set of cultures was started from material gathered at Rothiemurchus, Inverness-shire, during the autumn foray this year. Fruit bodies formed and ripened on the same media.

(*Accepted for publication* 30 *September* 1938)

(*Photo. J. A. Crabbe*)

A NEW SPECIES OF *UMBILICARIA* FROM THE ANTARCTIC

By ED. FREY and I. MACKENZIE LAMB

(With Plates XVIII and XIX)

Umbilicaria antarctica E. Frey & M. Lamb, sp.nov.

Diagnosis: Thallus monophyllus, usque ad 18 cm. diam., siccus rigidus, madefactus coriaceus, margine irregulariter lobatus, compluribus locis laceratus, increbre perforatus, superne in statu sicco pallido-badius vel ochraceo-badius vel helvolus, peripheriam versus sordide purpureo-fuscescens, in medio minutissime rimulosus rugulosus, in partibus marginalibus levior, partim subtilissime albido-pruinosus, haud nitidus; subtus ater, nec granuloso-areolatus nec trabeculatus, sed minute rugulosus vel verruculosus, circum umbilicum levis glaber, alibi rhizinis crebre vestitus; rhizinae atrae vel pallide fuscae saepe ramosae acuminatae teretes vel plus minusve complanatae.

Apothecia passim numerosa, 0·8–1·5 mm. diam., sessilia, basi bene constricta, primo simplicia orbicularia margine proprio integro mediocri, deinde convoluto flexuoso; disco atro, minutissime scabrido, haud nitido, interdum leviter indistincte umbonato, sed numquam gyroso.

Thallus crassit. 350–550 μ, superne strato incolorato irregulari 6–10 μ crasso cellulis morbidis hyalinis vacuis leptodermaticis 4–6 μ diam. obtectus; *cortex superior* 20–35 μ crassus, pallide lutescens, cellulis angulosis vel subrotundis plus minusve isodiametricis 4–7 μ diam., passim seriebus verticalibus dispositis (parietibus 1–1·5 μ crassis, pallide lutescentibus). *Stratum gonidiale* interruptum, irregulariter terminatum, 90–105 μ crassum; *gonidia* protococcoidea, pallescentia, plus minusve rotunda, 8–12 μ diam., pariete incolorato vix 1 μ crasso. *Medulla* haud inspersogranulata, sed omnino hyalina incolorata, e hyphis aut arcte vel sat laxe intertextis aut passim stricte conglutinatis, praecipue horizontaliter percurrentibus, 3–5 μ diam., valde pachydermaticis (parietibus usque ad 2 μ crassis). *Cortex inferior* 45–70 μ crassus; parte exteriore 8–24 μ crassa fusca, e cellulis irregulariter acervatis plus minusve rotundis 6–8 μ diam. (parietibus obscure fuscis circ. 1 μ crassis); parte interiore incolorata, e hyphis anastomosantibus conglutinatis irregulariter percurrentibus valde pachydermaticis (luminibus fistulosis 1–1·5 μ latis). *Rhizinae* cellulis obscure fuscis iis partis exterioris corticis inferioris similibus obductae, intus

incoloratae, hyphis dense conglutinatis longitudinaliter parallelis valde pachydermaticis.

Apothecia lecideina; *amphithecium* zona externa 8–15 μ crassa obscure fusca, cellulis fuscis iis in parte exteriore thalli corticis inferioris similibus, intus incoloratum, hyphis conglutinatis anastomosantibus irregulariter percurrentibus pachydermaticis (luminibus fistulosis 1–2 μ diam.). *Hypothecium* fuscum, centro plus minusve obconicum, utrimque parathecium exiguum formans; fere paraplectenchymaticum, hyphis arctissime intertextis 4–7 μ diam., leptodermaticis (parietibus vix 1 μ crassis, secretione fusca oneratis). *Hymenium* 100–130 μ altum, lamina tenui visum pallide fuscescens, continuum, epithecio obscure fusco; *paraphyses* incoloratae, 2–2·3 μ crassae, saepe ramoso-connexae, ad septa vix visibilia haud constrictae, apicibus non aut parum incrassatae, ibidem secretione fusca irregulariter oneratae. *Asci* inflato-clavati, longit. 35–55, crassit. 9–15 μ, pariete incolorato usque ad 3 μ crasso (apice ad 13 μ crasso), plasmate saepe luteo-fuscescenti. *Sporae* 4–6 (–8) nae, simplices, incoloratae, ellipsoideo-ovatae (pariete levi 1–1·5 μ crasso), longit. 15–16, crassit. 7–7·5 μ.

[*Pycnidia* non visa.]

React. chem.: Cortex superior $CaCl_2O_2$ distincte roseo-rubescens, medulla immutata.—Hymenium iodo persistenter caerulescens.

Loc.: Regio antarctica: South Orkneys, Signy Island, leg. A. G. Bennett, 1915. (Typus in herb. Mus. Brit. et fragmentum in herb. E. Frey.)

Icon.: Pl. XVIII, fig. 1 (part of the upper side); Pl. XIX, fig. 1 (part of the lower side); Pl. XVIII, fig. 2 (apothecia, magnified 4 times).

This imposing species belongs to the section Polymorphae of *Umbilicaria*, subgenus *Gyrophora*, and in respect of thalline morphology shows a close resemblance to *Umbilicaria vellea*; it is hard to distinguish sterile specimens from that species by superficial examination alone, the somewhat flattened rhizines being the only macroscopic criterion in the absence of apothecia. Such sterile specimens can be determined with certainty only by microscopical examination of thallus sections, in which the following points are worthy of note: (*a*) the subgonidial hyphae are not granulate-inspersed, as in *U. vellea*; and (*b*) the lower thalline cortex is in its inner part formed of conglutinated anastomosing pachydermatic hyphae with fistulose lumina 1–1·5 μ diam., whereas in *U. vellea* this part of the lower cortex is made up of isodiametric, more or less angular, thick-walled cells.

When apothecia are present their simple non-gyrose character is diagnostic. The spores are also larger than in *U. vellea*, which has spores 9–12 × 6·5–8 μ.

From *U. Dillenii*, the only other species with which it might be confused, it may readily be distinguished macroscopically by its

roughened upper surface and almost smooth (not granulate) under surface between the rhizines.

U. antarctica has been placed in the Polymorphae rather than the Velleae section on account of (*a*) the smooth apothecial disk (rare in Velleae, but present in *Umbilicaria virginis* of the Polymorphae), (*b*) the anatomy of the thallus and particularly of the apothecia, and (*c*) the often distinctly flattened rhizines, similar to those of *U. cylindrica* and *U. virginis*.

Var. ***subvirginis*** E. Frey & M. Lamb, var.nov.

Diagnosis: Thallus monophyllus, usque ad 2 cm. latus (vel etiam major?), siccus rigidus, madefactus laxus, margine irregulariter lobatus, pro parte laceratus vel diffractus; superne pallide glauco-murinus, peripheriam versus plus minusve sordide griseus; superficie minutissime et irregulariter verruculosus vel rimuloso-rugulosus, in statu adultiori fere rimosus vel diffractus vel quasi sulcatus, opacus; subtus ater aut sordide fuscus, fere levis, circum umbilicum glaber, alibi rhizinis plus minusve dense vestitus. Rhizinae ad basin atrae, rotundatae vel rarius planae, simplices vel parce digitatoramosae, apicem versus ochroleucae vel glauco-ochraceae. Umbilicus validus, valde stipitatus.

[*Apothecia* non visa.]

Thallus crassit. 240–450 μ, superne strato necroso incolorato 10–50 μ crasso cellulis rotundatis hyalinis vacuis leptodermaticis 4–6 μ diam. irregulariter obtectus; *cortex superior* 25–50 μ crassus, luteolus vel luteo-fuscescens, pro maxima parte paraplectenchymaticus, cellulis subrotundatis vel rotundato-angulosis, parietibus 0·7–1·2 μ crassis, luminibus cellularum 2–5 μ diam.; *stratum gonidiale* inter hyphas praecipue laxe verticaliter adscendentes 4–6 μ diam. (parietibus 0·8–1·3 μ crassis) irregulariter impositum, fere continuum, 60–130 μ crassum; *gonidia* protococcoidea, laete viridia, plus minusve rotundata, 6–12 (–15) μ diam., pariete incolorato vix 1 μ crasso. *Medulla* nec inspersa nec granulata, hyalina incolorata, e hyphis laxe intertextis et irregulariter (basin versus praecipue horizontaliter) percurrentibus, 3–6 μ diam., pachydermaticis (parietibus 1–2 μ crassis). *Cortex inferior* 30–50 μ crassus; parte exteriore 10–20 μ crassa fusca, e cellulis rotundatis, 5–8 μ diam. (parietibus obscure fuscis 0·8–2·0 μ crassis) irregulariter coacervatis vel agglomeratis; parte interiore incolorata, e hyphis conglutinatis anastomosantibus et irregulariter percurrentibus eximie pachydermaticis (tantum luminibus fistulosis 1–2 μ diam. visibilibus). *Rhizinae* extrinsecus cellulis obscure fuscis iisdem ac in corticis exteriore parte inferioris obtectae, intrinsecus incoloratae, hyphis pachydermaticis longitudinaliter parallelis stricte coalitis.

[*Pycnidia* non visa.]

1
2

1
2

React. chem.: Cortex superior $CaCl_2O_2$ indistincte roseolus, medulla immutata.

Loc.: Regio antarctica: South Victoria Land, Cape Sastrugi, Evans Cove, leg. British Antarctic Expedition *Terra Nova*, 1910. (Typus in herb. Mus. Brit. et fragmentum in herb. E. Frey.)

Icon.: Pl. XIX, fig. 2.

This is the specimen listed as "*Gyrophora vellea*" by Darbishire in *Brit. Antarct.* (*Terra Nova*) *Exped.*, 1910, Bot., Part III, Lichens, p. 32 (1923).

On account of the scantiness of the material available for investigation, and the fact that it consists apparently of depauperate individuals, the systematic affinity of this variety remains somewhat uncertain. Apart from the dark underside, the plants show a marked resemblance to depauperate forms of *Umbilicaria virginis*, as it is found on the highest summits of the Alps and in the Arctic. The anatomical characters, on the other hand, show an approach rather to those of *U. antarctica*. It is by no means impossible that the true *U. virginis* or a form of it similar to the above variety may eventually be found to occur in the Antarctic. Until this proves to be so, however, we prefer to relate the new variety to *U. antarctica*. It may indeed be an intermediate condition between the latter species and *U. virginis*. The close systematic proximity of these two species is shown by the similarity in their anatomy, apothecia, and rhizines. One might consider them as vicarious species, which together form a bipolar element. In this connexion reference may be made to the obviously closely related Polymorphae from Africa and New Zealand: *Umbilicaria aprina* Nyl. and *U. Haumaniana* Frey in Africa, *U. subaprina* Frey and *U. Zahlbruckneri* Frey in New Zealand, all of which, with the exception of *U. Haumaniana*, possess a smooth apothecial disk like that of *U. virginis*.*

EXPLANATION OF PLATES XVIII–XIX

Plate XVIII

Fig. 1. *Umbilicaria antarctica* E. Frey & M. Lamb, n.sp.; part of upper side of type specimen before division (natural size).

Fig. 2. *Umbilicaria antarctica* E. Frey & M. Lamb, n.sp.; apothecia of type specimen (four times natural size).

Plate XIX

Fig. 1. *Umbilicaria antarctica* E. Frey & M. Lamb, n.sp.; part of lower side of type specimen (natural size).

Fig. 2. *Umbilicaria antarctica*, var. *subvirginis* E. Frey & M. Lamb, var. nov.; part of type material (natural size).

* See Frey in *Ber. Schweiz. Bot. Ges.* XLV (1936), 198–230, and XLVI (1936), 412–44.

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THE OCCURRENCES AND SYSTEMATIC POSITION OF THE VESICULAR-ARBUSCULAR TYPE OF MYCORRHIZAL FUNGI

By E. J. BUTLER

(*Agricultural Research Council*)

(With Plate XX and 3 Text-figures)

Historical

The vesicular-arbuscular type of fungal endophyte of the roots of plants has been frequently described. The first references to it, if for the moment one excludes the endophytes of the Lycopodiaceae whose affinities are doubtful, and those of the Orchidaceae, Ericales (including Epacridaceae and Pyrolaceae), and Empetraceae, which are morphologically quite distinct, appear to have been in the Ophioglossaceae, where various early observers had seen endophytic fungi no doubt belonging to this group, though their special characters were not recognized. A more certain identification can be made of the fungus found in the roots of many flowering plants by Schlicht (1889). In the same year Kühn (1889) described and figured thin, round or elongated bladders ("Blasen") with the most various protrusions, formed on fine hyphae which enter the cells from an intercellular mycelium in the inner cortex of underground roots of Marattiaceae (*Angiopteris evecta* and *Kaulfussia aesculifolia*). It seems impossible to agree with Janse that these bodies are analogous with the vesicles described by the latter writer. There can be no doubt, however, that Schlicht saw both vesicles (one of which he figures in his Fig. 5) and sporangioles, which are only a late stage of the arbuscules (Fig. 6), in *Paris quadrifolia*, though he did not recognize them as specific organs of the fungus. He also noted that the mycelium within the tissues was very sparingly septate and that by a partial fusion of the membrane there were formed from the fungal mass within the cells thick clumps of an ill-defined, mostly cauliflower-like form which could not always be recognized as taking their origin from fungal hyphae. These bodies, from which the inner cortical cells were free, were at first hyaline, then light yellow, turning ultimately to yellow-brown; it is now known that such clumps are the last stages of the sporangioles. In infected roots the clumps were mostly found at some distance behind the growing point, whereas nearer the growing point the fungus remained filamentous. In

Leontodon autumnalis similar glassy homogeneous fungus masses were found in the inner cortical cells, where they persisted as clumps of variable but mostly cauliflower-like form. This was regarded as a resting or dead stage of the mycelium. Most of the seventy-one species of plants in which he found the endophyte, including other Compositae, Umbelliferae, Rosaceae, Gentianaceae, etc., had the *Leontodon* type of distribution of the fungus, which was such that the central cylinder of the absorbing roots was practically surrounded by a mantle of fungus elements; even in *Paris*, though the inner cortex was free, all nutriments from the soil had to pass through the fungus-containing cells to the vessels. No injury was caused to the roots; the cell nucleus, near or around which the clumps formed, persisted and was very large; there was no indication of parasitism. Frank's views (1885, 1887) as to the significance and functions of the superficial or "ectotrophic" type of mycorrhiza found in trees and the internal or "endotrophic" forms of the Ericales and Orchidaceae, in Schlicht's opinion received a wide extension by the latter's further discovery of endotrophic mycorrhiza in such a large range of plants.

It would seem that M. Treub (1885) saw this type of endophyte in sugar-cane roots in Java some years earlier, but since he does not mention the vesicles or sporangioles but only states that in the inner cortical layers of the fine roots the fungus fills the cells with a dense finely branched mass, so fine that it is very difficult, even at high magnifications, to make out a filamentous structure, there cannot be absolute certainty that he observed the mycorrhizal endophyte in question here. Nevertheless, since the vesicular-arbuscular mycorrhiza is common in sugar-cane and since Treub noted that every adjoining cell may be thus filled, that the central cylinder was not penetrated, and that the fungus caused no apparent injury to the root cells (though heavily infected roots were dead), the circumstantial evidence that he was dealing with the endophyte is strong. Wakker and Went (1898) believed that the fungus that they described as "Wortelschimmel No. 1" is sugar-cane roots in Java was the same as Treub's species, and as their illustrations of the vesicles are amongst the best that have been published, there is not any doubt that they were describing the vesicular-arbuscular organism, though they make no mention of Janse's (1896) work on related fungi and do not seem to have seen sporangioles. They do not accept Treub's identification of it as probably a *Pythium* (based on the fact that he got a growth of a *Pythium* from pieces of infected roots placed in a moist chamber), but agree with A. Tschirch's view (1891) that it is to be ranked with Frank's endotrophic mycorrhiza, whether these fungi be regarded as weak parasites or not.

Wakker and Went were apparently the first of the very few observers

who traced the vesicular fungus back into the soil around the roots, and they give two excellent illustrations (copied in Text-fig. 3E) of the vesicles as they occur on free hyphae in the soil, and others showing them in the tissues of the root.

Besides sugar-cane, the same fungus was reported by Wakker and Went to occur in the roots of other species of *Saccharum* and in various other grasses, but it was absent from the roots of rice.

In 1896 appeared Janse's classical paper on the root endophytes of Javanese plants, in which the vesicles and sporangioles are described under these names for the first time and recognized as special organs of the endophytes which he found in sixty-nine of the seventy-five plants in fifty-six families that he investigated in Java. These included Bryophytes, Pteridophytes, Gymnosperms, Monocotyledons and Dicotyledons. Janse considered that the endophytes in these plants were closely related except those in *Zoopsis* (Jungermanniaceae), *Lycopodium* and *Psilotum* (Lycopodiales), which had no sporangioles and doubtful vesicles (unless the small terminal swellings found in subepidermal cells of *Psilotum* are vesicles, which he "did not dare to affirm"), Orchidaceae, which had no vesicles and aberrant sporangioles that, he thought, might not be homologous with those in other Monocotyledons studied, and Ericaceae, which differed from the rest in important characters though he found in them small sporangioles suggesting that these differences may not be absolute.

The systematic relationships of these endophytes could not be determined. All those seen by Janse showed certain features of relationship but they could at least be separated into groups, such as those characteristic of the Orchidaceae, those of the Ericaceae, that in *Zoopsis*, those of *Psilotum* and *Lycopodium*, all of which showed considerable divergences from the general body of forms studied.

The introduction of the term "arbuscule" for the haustorium-like structures which ultimately bear the sporangioles is due to Gallaud (1905). In his extensive study of the morphology of a large range of root endophytes of the type here in question, vesicles and arbuscules were found in all except those of the Orchidaceae. Janse's sporangioles were considered to be later transformations of the arbuscules due to digestion of the latter by the cell. The endophytes found in the Hepaticaceae and, according to the descriptions of other authors, those of the prothalli of the Lycopodiaceae, were considered by Gallaud to be rather distinct from those in other plants studied, while those of the Orchidaceae diverged widely from the rest. As is now well known, the orchid mycorrhiza are produced mostly by fungi of the imperfect genus *Rhizoctonia*, and their perfect stages, where known, are Basidiomyces far removed from the "phycomycetoid" types of fungi to which the vesicular-arbuscular endophytes belong.

Peyronel (1923–4) has carried out one of the most important

studies of the endotrophic mycorrhiza of common field and woodland flowering plants that has been made. The endophytes that he found in 132 of the 151 (mainly alpine) plants in thirty-six natural orders examined belonged to two distinct types. One, which Peyronel terms the *Rhizoctonia* type, was the only kind found in the Orchidaceae and occurred also in many other roots, often in company with the other which he called the "Phycomycetoid" type. The latter is the arbuscular-vesicular endophyte of earlier authors; it has an extensive mycelium outside the roots, on which extramatrical vesicles are borne. The fungus also grows saprophytically after the death of infected roots, when it may enter the central cylinder which in living roots is never invaded. It can spread widely through soils that are not too dry or compact. Its development is extensive in mossy soils (*Sphagnum*, *Polytrichum*, etc.) where *Viola palustris* is often associated, and also in sandy soils with *Viola biflora* and *Circaea alpina* if sufficiently moist.

Many other papers have been published dealing with particular instances of the formation of this type of mycorrhiza. They are fully referred to in Rayner's (1927) book. Those mentioned above include the chief in which extensive comparative studies have been made.

Distribution and morphology

(1) *Flowering plants*

The vesicular-arbuscular or phycomycetoid type of endophyte has been hitherto reported in the roots of several hundred flowering plants. I have seldom failed to find it in the plants of arable and garden soils in India and it appears to be equally common in England. Sometimes the search has had to be prolonged as, for instance, in the common cereals, and I have not seen it in rice. In orchard and plantation crops such as the tree and bush fruits and the tropical and subtropical plantation crops like tea, coffee, rubber and citrus, it is common; and in a more limited examination of forest soils I have found it in India invariably and luxuriantly developed in bamboo roots and in the roots of some of the trees used for shade in tea gardens, such as *Albizzia stipulata*. The regularity of its occurrence in some perennial plants and its incidental presence in some annual field crops is probably merely the result of the greater chance which an organism growing in close association with living roots has of persisting indefinitely and passing from the older to the more newly developed roots in the former class. In annuals, much of the fungus perishes with the roots, and survival is restricted to the thick-walled resting mycelium and vesicles found in the soil when the new crop is sown. It is of interest to note that, though I have found this type of mycorrhiza on a few roots of cotton seedlings in the cotyledonary

stage in the black cotton soil of Gujerat and once traced infection back to a piece of old resting mycelium bearing an empty vesicle, the endophyte was scarce in this cotton, whereas in the Sudan the young cotton roots are commonly transformed into mycorrhiza and the extramatrical development of the fungus is very luxuriant. Pl. XX, figs. 1, 2 shows the appearance of the mycelium and vesicles in a tangled growth of the endophyte and other fungi (chiefly of the *Rhizoctonia* type) obtained around young cotton roots kindly sent by Mr R. E. Massey, Government Botanist, Sudan, in 1934. In the very unusual soil and cultivation conditions of the Gezira cotton area of the Sudan the mycorrhiza are reported to have become abundantly developed by the third week from sowing, the endophyte increasing in prevalence for about another three weeks and then remaining somewhat constant for a further period of about two months, after which a definite decline sets in.

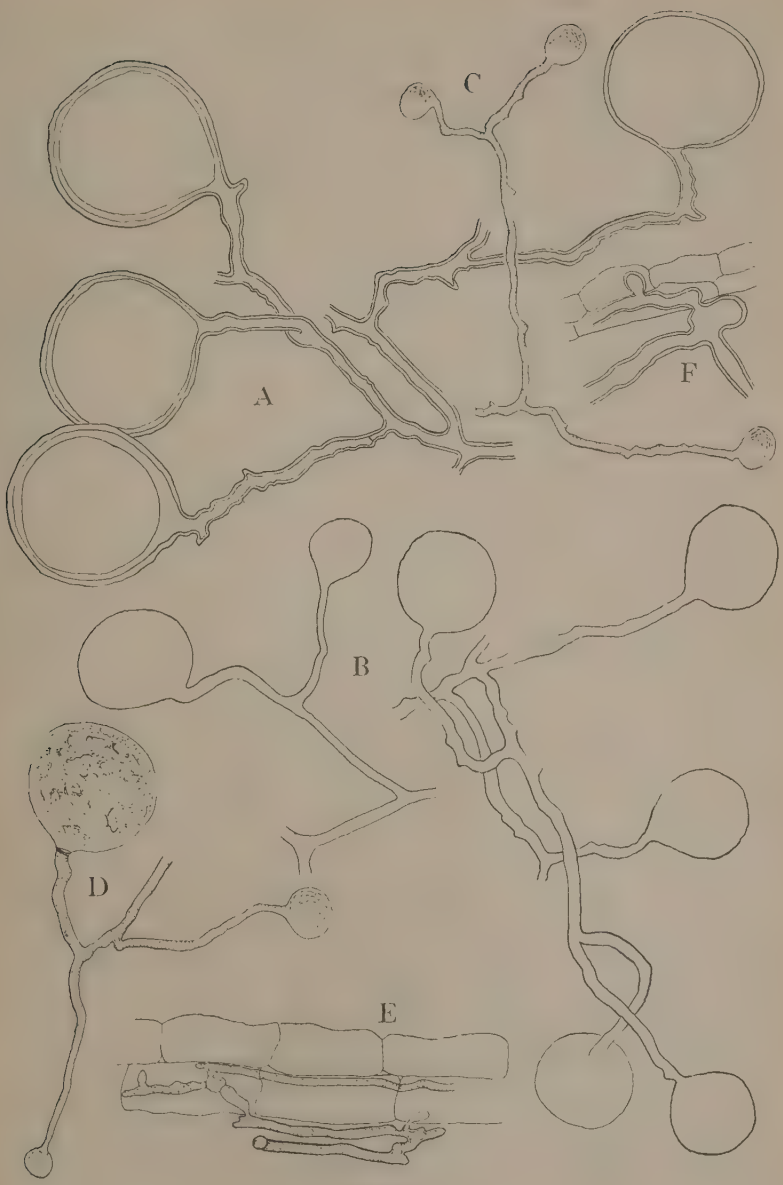
In three of the Leguminosae studied in India, the large tree *Albizzia stipulata*, pigeon pea (*Cajanus indicus*) and ground-nut (*Arachis hypogaea*), the phycomycetoid endophyte was found on rootlets which also bore the ordinary bacterial nodules common to this order. In one specimen the mycorrhiza bore two nodules near together and the fungus was found in the short segment of root between. The presence of one symbiont did not in any way seem to impede the development of a second.

The extramatrical mycelium of the fungus (Text-fig. 1), which can always with patience be traced back from the root into the soil, consists of usually stout, tortuous-angular hyphae marked by characteristic unilateral angular projections. The hyphae are at first hyaline and thin walled, but frequently turn honey-yellow on ageing and thicken their walls, sometimes very markedly (Text-fig. 1 A, C), by internal deposition of material. In this condition the hyphae are rigid and rather brittle. Septa are irregular and usually sparse or even absent from considerable parts of the mycelium. When present they may separate an empty from a full, or at times a thick-walled from a thin-walled segment so as to form a persistent hypha which presumably helps to secure the vegetative propagation of the fungus.

McLuckie and Burges (1932) comment on the dimorphism of the

Legend to Text-figure 1.

Text-fig. 1. A. Mycelium of *Rhizophagus* sp. bearing four large terminal, thick-walled vesicles; from soil around cotton roots, Gezira, Sudan. ×480. B. Two hyphae of same bearing, respectively, five and two less mature vesicles with thin walls and no basal septum. ×480. C. Early stage in formation of extramatrical vesicles of same. ×480. D. A hypha of same bearing one older vesicle with a basal septum and others in earlier stages. ×480. E. Penetration of cotton root by a hypha from the external mycelium of same. A longitudinal runner hypha has formed in the base of the outer cell layer. ×480. F. Old hypha with thickened, rigid walls, showing mode of entry with appressorium-like swelling into *Abutilon* root, Kew.



Text-fig. 1.

mycorrhizal endophyte of *Eriostemon Crowei* outside and inside the root; the external hyphae are thick-walled, brown and septate, but they become thin-walled and are mostly unseptate after entering the root. Others have also noted the septation of the external mycelium, but in the specimens I have seen, regular septation does not occur, none was found in actively growing hyphae, and the differences in the thickness and colour of the walls become less marked as the internal mycelium ages.

Entry takes place usually through a cell of the epidermis of the young root behind the meristematic region, but sometimes through a root hair. McLuckie and Burges estimated the average number of penetrations in the mycorrhiza of *Eriostemon* and found them to range in different roots from 2·56 to 4·1 per sq. mm. of root surface. This is probably an exceptionally high number. The entering hypha often swells up into a kind of appressorium at the point where penetration occurs. In the example figured in Text-fig. 1 F, the external hypha was 10 μ in diameter and in the mycelium from around cotton roots shown in A of the same text-figure the hyphae measured up to 11 μ in breadth, the thick wall being about 2·2 μ broad in the smooth parts and 3·3 μ where angular projections occurred.

After entry the hypha usually passes down through one or two layers of cells and then either enters the intercellular spaces of the cortex or continues within the cells, or does both. Occasionally, as in sugar-cane, the hyphae pass lengthwise through the outer cells; Wakker and Went (1898) show a stout, colourless, thick-walled filament passing longitudinally through the walls of eight superficial cells, without branching. While within the cells, the hyphae often show a tendency to coil, and even in the external layer a single loop is sometimes seen. This tendency to coil is characteristic of all the endophytes even where, as in the orchids and heaths, the fungi are not related to those under discussion here. Sometimes the cells are filled with a closely pressed mass of strands. In the deeper layers the direction of the main hyphae is generally parallel to the long axis of the root (Text-fig. 2 G). The young hyphae have thin walls but, as in the external mycelium, the wall may thicken with age (up to 2 μ) by internal accretion. Septation is rare but irregularly placed septa may develop, especially in old hyphae. Where the hyphae pass from cell to cell they may be much constricted. Branching is not extensive in the longitudinal hyphae, excepting for the formation of peculiar lateral, fine, flattened thread-like filaments (Text-fig. 2 G) which often come off from the angular or knob-like irregularities in the walls of the main hyphae. The fate of these fine branches was not followed, but they are probably the remains of arbuscular stalks whose sporangioles have been "digested", or are homologous with these. Peyronel (1923–4) describes the formation of lateral tufts of

fine, regularly septate, rhizoid-like branches on the external mycelium, but these I have not seen.

The vesicles which, when present, are the most noticeable organs of the fungus, develop terminally, rarely intercalary, on the intramatrical mycelium, whether this is in (Text-fig. 2 G) or between the cells, and also on the mycelium in the soil around the roots (Text-fig. 1 A–D). They may be oval, pear-shaped, round, or irregular (especially when confined within a cell or intercellular space). The character which marks them off from most other comparable organs in the fungi is their open communication with the hypha on which they are borne (Text-fig. 1 B, Text-fig. 2 G, Text-fig. 3 E). A basal septum is not normally formed, though when mature the lumen of the vesicle may sometimes be occluded either by the late formation of an inner wall surrounding the cavity of the vesicle (Text-fig. 1 A) or by a plug-like septum in the neck of the stalk (Text-fig. 1 D), similar in its appearance to the septa found in old hyphae.

The wall of the vesicle is at first thin and colourless but it thickens by the deposition of a layer (possibly more than one) on the inside and then may turn pale yellow to brownish. When a mature thick-walled vesicle is crushed the separation of the inner from the outer wall sometimes results. The contents are multinucleate, at first watery, then granular, and at maturity full of droplets of oil or fat. This abundance of fat has been noticed by many and is especially stressed by Miss McLennan (1926) in her account of the endophyte in the roots of *Lolium temulentum*. Old vesicles are often almost emptied of their contents.

The size of the vesicles is variable; it is often considerable, so that the vesicles may be visible to the naked eye. In *Abutilon* the range I have found was 30–90 × 20–40 μ, the larger sizes being confined to the extramatrical mycelium (Text-fig. 3 A, D). In the external vesicles from the vicinity of cotton roots from the Sudan (Text-fig. 1 A) the largest seen was 90 × 88 μ but within the roots the maximum noticed was 66 × 40 μ and few were above 40 × 30 μ. Wakker and Went's (1898) sugar-cane fungus has vesicles which (from their Fig. 7) may be up to about 93 μ in diameter. The largest seen by Janse (1896) were 135 × 35 μ in *Schismatoglottis* and 100 × 27 μ in *Piddingtonia*, while the smallest were up to 20 × 20 μ in *Cotylanthera* and up to 30 μ in *Turpinia*. In *Eriostemon Crowei* McLuckie and Burges (1932) give the *average* size as 68 × 53 μ. Gallaud (1905) found some up to 80 × 60 μ in the plants he examined. Though there are grounds for considering it to be likely that several allied species of fungi are capable of inducing the formation of this type of mycorrhiza, it is not possible on present knowledge to distinguish those seen in flowering plants by any constant morphological feature such as the size or shape of the vesicles.

Vesicles are not found in every infected root at a single examination. Janse, for instance, recorded them in only twenty-one of his sixty-nine species and I have failed to see them quite frequently. On the other hand, Gallaud got them in all his species except the orchids. The probability is that failure to find them is due to the examination being made at one stage of growth only, and that most of the older specimens contain them.

The other characteristic organ of these endophytes, the arbuscule-sporangiole apparatus, develops wholly within the cells and is always produced. It is often (e.g. in *Abutilon*) confined to the inner cortical layers, usually those next outside the endodermis. Sporangioles have, however, been described in certain species in all parts of the cortex. The arbuscule (which has been copiously figured by Gallaud (1905) and others) arises from any part of the main hyphae. The primary branch or stalk may be stout or fine or merely (when the origin is intracellular) a short projection from the side of a coiled hypha. This branch usually divides within the cell, sometimes several times, and then ends in a close "brush" of dichotomously branched terminal filaments not exceeding 0·5 μ in diameter, on each of which a sporangiole is borne. The sporangiole is a very thin-walled sac, which soon loses its smooth contour and becomes lumpy or mammilate. It then undergoes some kind of change which ends in its contents, largely of a fatty nature, becoming mingled with those of the host cell. It does not seem to burst but rather to coagulate and then undergo "digestion". Individual sporangioles vary greatly in size, the limits given by Janse being 2·5–23 μ.

(2) *Cryptogams*

In sporangioles of the type found in *Abutilon* the fine details of the arbuscules are more difficult to make out than might be suspected from the drawings of Gallaud (1905) which are evidently somewhat schematized. In certain plants, however, the sporangioles preserve their entity for a considerable time. Thus, the large (10–18 μ) individual sporangioles in the roots of *Ophioglossum vulgatum* examined at Kew (Text-fig. 3 F) form a cluster on short stalks near the tip of an exceedingly fine hair-like branch given off laterally from a main hypha. At first their contents are rather fluid and stain well with haematoxylin. They are turgid when young, but later may either collapse or, as seems to be more usual, become more solid while still remaining discrete and are then gradually eaten into irregularly from the outside by a "digestive" process of the host cell. In these roots, which have no root hairs, there is a broad cortex in three zones. The outermost of these, composed of two or, rarely, three layers of cells, remains free from the fungus except for an occasional entering

hypha which penetrates, more or less vertically, to the second zone. This consists of about four layers and contains the mass of the fungus. The main hyphae run in general longitudinally and measure from 3–7 μ in diameter, the broader having a distinctly double contoured wall. They pass either between or through the cells (though the mycorrhiza of *O. vulgatum* is placed by Gallaud (1905) in his second or *Paris quadrifolia* series, and was regarded by him as wholly intracellular, in contradistinction to that of *Angiopteris* which he referred to his first series, where the mycelium is mainly intercellular), but when passing through a cell are often enclosed in a sheath similar to that deposited by the cell around the invading hyphae of parasites like *Ustilago* or *Sclerospora*: similar peg-like sheaths were observed by Jeffrey (1897) in *Botrychium* prothalli and by Lang (1899) in those of *Lycopodium*, surrounding the hyphae after penetration of the cell wall. The hyphae stain brilliantly with safranin, which leaves the sporangioles and their stalks unstained. Vesicles and sporangioles both occur in this zone, the former measuring from 22 to 34 μ in diameter and resembling in all respects, except their smaller size, those of the *Abutilon* endophyte. Organic continuity between the hyphae bearing vesicles and those with sporangioles was traced repeatedly. Inside this zone are six or seven layers of rather collenchymatous cortical cells quite free from the fungus and containing starch, which is absent from the cells containing the fungus. That starch is not ordinarily found in the infected cells has been reported by several observers and the significance of this in the nutritional relations of endotrophic mycorrhiza has again recently been stressed by Endrigkeit (1937).

An entirely similar endophyte was found in the roots of *Botrychium lunaria*, but that in some prothalli of *B. virginianum* kindly supplied to me by Mr L. Boodle, who had received them from Prof. E. C. Jeffrey, differed sufficiently widely from the type in the sporophytic roots of the Ophioglossaceae to be regarded as at least belonging to a distinct species. The endophytes of these plants have been long known, as they were seen by Russow (1872), Holle (1875), and Kühn (1889) in the roots, and by Jeffrey (1897), Lang (1902), Bruchmann (1904) and others in the prothalli. The closely coiled slender hyphae, doubtful occurrence of sporangioles, and rather aberrant type of vesicle found in the gametophytes of the Ophioglossaceae suggest that the endophytes of these prothalli are rather widely separated from those found in roots but still probably belong to the same group of fungi. Endophytes have also been frequently and from a very early period recorded in the liverworts and here also it seems probable that more than one type is concerned. The fungi described and figured by Miss Ridler (1922, 1923) in the thallus of *Pellia epiphylla* and *Lunularia cruciata* are clearly of the ordinary type, with abundantly

developed thick-walled vesicles containing oil, and large arbuscules, but that in the sporophyte of *Pellia* seems to be quite distinct, with uniform and regularly septate hyphae and without special organs. The endophyte in the gametophyte was not observed to do any injury except that it caused starch to disappear from infected cells, but that in the sporophyte sometimes had parasitic tendencies. Distantly and irregularly spaced septa were found in the phycomycetoid endophyte of both plants studied by Miss Ridler, especially in the mycelium in the rhizoids, and are also mentioned as sometimes occurring in the similar fungus in *Fegatella conica* by Maria Bergamaschi (1932), whose figures of the endophyte of *Lunularia cruciata* clearly show that the vesicles in this plant, as in those earlier mentioned, are not isolated by a septum from their stalks.

A similar range of variation in the size of the vesicles is found in the Cryptogams as in the Phanerogams. Janse (1896) found vesicles measuring $105 \times 55\,\mu$ in *Selaginella*, while Lang's (1902) largest figured in *Helminthostachys* prothalli was (by calculation from the figure) $34 \times 26\,\mu$, and the largest I found in *Ophioglossum* roots measured $34\,\mu$ in its longest diameter.

The endophytes found in the prothalli of *Lycopodium* seem from the literature to have points of similarity to those of the thalloid Hepaticaceae and this is also the opinion of Gallaud. But Janse failed completely to find sporangioles in the species he studied and sporangioles do not seem to have been since recorded in prothalli of the Lycopdiaceae (unless the "clusters of spores" of Holloway (1920) and the "Ptyosomen" of Burgeff (1938) are such), so that the true affinities of their endophytes are still somewhat doubtful.

(3) *Fossil records*

This group of fungi are probably amongst the earliest of which fossil records have been preserved. Fungi resembling them have been found in the subterranean parts of the Psilophytales, the oldest of the land plants. In Kidston & Lang's (1921) account of the plants from the Rhynie Chert Bed of the Old Red Sandstone of Aberdeenshire there is described, under the name *Palaeomyces Asteroxyli*, a fungus very regularly found in the inner cortex of rhizomes of *Asteroxylon Mackiei* and of the basal regions of stems having the transition structure between rhizome and stem. The fungus consists of stout and fine non-septate hyphae, usually intercellular (except where one penetrates a superficial cell), and often bearing terminal vesicles which are thin-walled and usually not cut off by a septum from the parent hypha. The vesicles attain a size of about $80\,\mu$ and the hyphae vary from 4 to $20\,\mu$ in breadth. One of the figures of this fungus, from an untouched photograph, is reproduced from Kidston & Lang's paper

in Pl. XX, fig. 3. Another fungus, called Fungus no. 6, was found in the same locality in a decaying stem of *Rhynia major* and is stated to present resemblances to *Palaeomyces Asteroxyli*. It also had a branched, non-septate mycelium swelling into moderately small vesicles, but adjoining stems of the same plant showed oval, thick-walled resting spores resembling those of the fungus named by these authors *Palaeomyces Gordoni*, in which the vesicles may develop into "chlamydospores" up to over 350 μ in diameter. It is considered by the authors to be not improbable that Fungus no. 6 is a similar fungus to *P. Gordoni* in an earlier or different condition of development. The figure reproduced in Pl. XX, fig. 4 shows that the vesicles of Fungus no. 6 are not separated from their stalk by a septum and are of about the same size as those of *Palaeomyces Asteroxyli*, the two figures having the same magnification.

The authors state that the fungi of the Rhynie peat, of Early Devonian age, resemble some of the fungal remains already known from the later Permo-Carboniferous rocks; *Peronosporites antiquarius*, for instance, is considered to show in its hyphae and vesicles or spores a resemblance to *Palaeomyces Asteroxyli* and *P. Gordoni*. Furthermore the resemblance of some of these fossil fungi to mycorrhizal fungi of living plants is remarked upon by Kidston and Lang, who state that while certain of the fungi (e.g. *P. Gordoni*) that they have found in the Rhynie Chert were evidently saprophytes associated with decaying tissue in various parts of the plants, the occurrences of others were more regular. In *P. Asteroxyli* the localization of the fungus to the intercellular spaces of the broad inner cortex is in support of the view that it was mycorrhizal, and the regularity of the association of fungus and higher plants, together with the occurrence of the former in the subterranean parts of the latter, they consider to be sufficient reasons to justify keeping open the question of *P. Asteroxyli* having been normally associated with its host when alive. Fungus no. 6 with the the other fungi found in *Rhynia* having vesicles or resting spores are apparent examples of active saprophytic growth, but the possibility that this was a further development of a mycorrhizal organism is not excluded by the authors.

As noted by Kidston and Lang, similar fungi have been described from Carboniferous strata. One of these from the Yorkshire Coal Measures, *Peronosporites antiquarius*, was mentioned by Carruthers in 1876 and more fully described by Worthington G. Smith (1877). It occurred in a *Lepidodendron* and was re-examined by Williamson (1881), who failed to find the spores in the vesicles and the septa in the hyphae or between the latter and the vesicles that Smith had figured. Seward (1898) also published a figure of it, drawn from one of Williamson's specimens. The vesicles formed in loose clusters on short, dichotomously branched, thick hyphae. In one of the vesicles

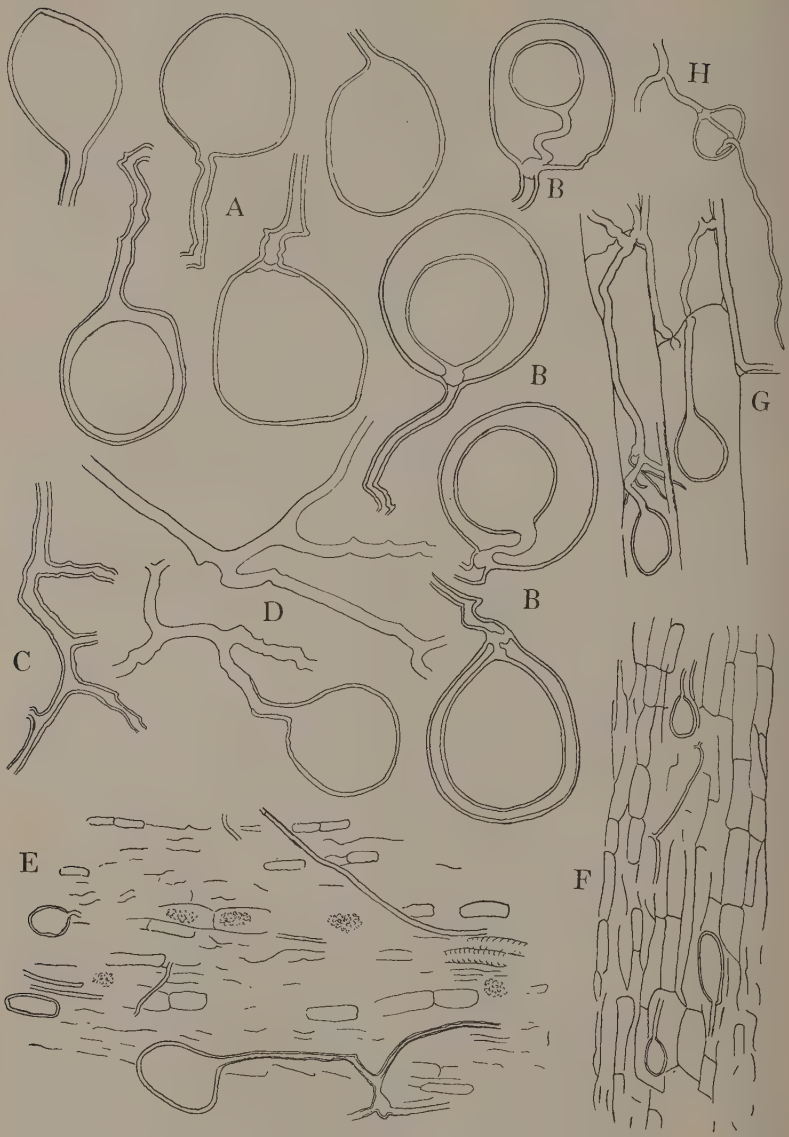
figured by Seward the open connexion of the vesicle with its bearing stalk is visible. Calculated from the given magnification this vesicle measures about $56 \times 43\,\mu$, while Smith's figures, similarly calculated, give a diameter up to about $45\,\mu$. Seward also gives a figure of a related type found by Cash and Hick in the Lower Coal Measures of Yorkshire, which is of interest because one of the two vesicles shows rather thickened walls. Another fungus described by Smith (1884) under the name *Protomycites protogenes*, from the rootlets of a *Lepidodendron* in a similar locality, differs from those mentioned above in that the round vesicle, measuring as calculated from the figure about $160\,\mu$ in diameter, resembles an oogonium and contains an inner oospore-like body about $100\,\mu$ in diameter. It will be seen below that this oospore-like appearance may be due to proliferation into the vesicle from the basal stalk or it might result from the separation of the inner membrane of a thick-walled vesicle.

Osborn (1909) found a much better representative of the group of endophytes here under consideration, in the rootlets of the Palaeozoic Gymnosperm genus, *Cordaites*, from the Lancashire Coal Measures. Large unbranched hyphae with very few or no septa occurred in the cortex, and dark masses, taken to be fungal clumps, in the cells of the inner cortical layers, but there were no traces of an endophyte in the endodermis or in deeper tissues. When the seemingly healthy rootlets were apparently full grown and about to form periderm he found large knob-like bodies with thickened walls, about $50\,\mu$ in diameter and apparently terminal on a hypha in connexion with the rest of the mycelium. Osborn figures a couple of typical vesicles at the ends of the obtusely dichotomous branches of a hypha, one of which appears to be in open communication with its stalk. This fungus was constantly present in the roots, which did not show signs of decay. Osborn states that he found exactly similar bodies in fresh roots of *Podocarpus cupressina*, a genus in which they had been already well described and figured by Janse (1896). He concludes that the structure in *Cordaites* is mycorrhizal. A much larger series of these roots, including some of Osborn's material, was subsequently studied by Halket (1930), who is satisfied that their endophyte, which was constantly present, is similar to the arbuscular-vesicular type in recent plant roots. The mycelium and vesicles are inter- and intracellular and septation is constant, though irregular and unevenly spaced. The arbuscules are clearly figured as short thick branches, ending in fine tufts, in which there is a tendency to obtusely dichotomous branching. They form in a regular "fungal zone" in the inner cortex. It is clear, therefore, that in Permo-Carboniferous times the fungi under discussion were already developed in structure little if at all different from those found living in association with plant roots at the present day.

In 1927 the writer received from Prof. F. J. Lewis, then Professor

of Botany in the University of Alberta, Canada, specimens of a fungus from the glacial clays underlying the peat bogs ("muskegs") common in the neighbourhood of Edmonton. In communicating them Prof. Lewis stated that fungus material of the same character occurs in the pure clay, sometimes associated with fragments of leaves and branches of *Sphagnum*. In the specimens which I retained, however, and from which the drawings in Text-fig. 2A–D were made, the material came from the basal one inch of amorphous peat resting on the blue clay in a muskeg eight miles west of Edmonton. The vesicles were in chestnut-brown clusters, resembling those from around cotton roots, but were remarkable not only by their size (up to $116 \times 103\,\mu$, range $60–116 \times 55–103\,\mu$) but because several of them (Text-fig. 2BBB) showed proliferation of the stalk and the formation of a second vesicle inside the first. Besides *Sphagnum* (the most abundant plant: *S. magellanicum*, *S. acutifolium*, *Sphagnum* spp.) Prof. Lewis identified material of *Ledum palustre* and *Oxycoccus palustris* with fragments of coniferous wood in other muskegs around Edmonton (cf. Lewis *et al.* 1926, 1928). Plant material, all of peat bog origin and mostly decomposed, is scattered in the clay in small quantity down to 3 m. Overlying the clay is a few feet of more recent peat, and some samples of this were sent later by Prof. Lewis. They contained typical mycelium and vesicles resembling in all respects the common endophyte of so many other modern plant roots. In one slide, from 3 dm. below the surface of the peat, a root occurred which clearly showed the fungus in mycorrhizal association for, in addition to a surface mycelium bearing vesicles, there were unmistakable hyphae, vesicles and arbuscules within the tissues (Text-fig. 2E). In this material the hyphae and vesicles occurred throughout the peat down to its junction with the clay at a depth of 1 m. 23 cm. The vesicles differed from those of the earlier material in being smaller and showing no tendency to form a second vesicle by proliferation into the cavity of the first.

The muskegs of Central Alberta, therefore, contain fungi of the group under consideration, both in the clay deposited by glacial action and in the overlying more recent peat. In the latter situation the material quite agrees with the well-known vesicular-arbuscular endophyte of modern plants and with the fungus described by Osborn and Halket in *Amyelon radicans* (*Cordaites*) from the Lancashire coal balls, and the fungus forms a mycorrhizal association with roots in the peat. In the clay the fungus is coarser, the vesicles show proliferation, and association with roots was not observed: indeed no roots could be identified with certainty in the material examined. That the fungi in the glacial clay and in the overlying more recent peat are closely allied there can be no question; except for the single fact that the older vesicles show proliferation they might be regarded as the same species.



Text-fig. 2.

Nature and functions of the vesicles and sporangioles

The vesicles have been considered by some to be food reserve stores, by others to be asexual spores or sporangia. Janse (1896) suggests that they are asexual cysts or resting spores and Gallaud (1905) that they also function as organs for the temporary accumulation of reserve food, especially where they are not cut off by a septum, when they may be found empty, probably through failure to mature and resorption of their contents. Miss McLennan (1926) regards the vesicles ordinarily as organs in which, though they may represent an abortive attempt at spore formation, the usual function is to store large quantities of fat which is later transferred to cells in which digestion is proceeding; in one root, however, she found several vesicles in which the contents had formed into rounded, thick-walled, spore-like bodies. The fact that the vesicle with these bodies which she figures is not occluded by a septum militates against its acceptance as a sporangium. Peyronel (1923–4), however, is satisfied that many of the vesicles develop into sporangia, spores forming after the vesicle contents are enclosed by the development of a basal wall. He figures the development of spore-like bodies in vesicles in a dead root of wheat. Further figures were reproduced in a paper published earlier by Peyronel (1923) but apparently written some months later than that cited above. If these are not to be regarded as representing true sporangia of the endophyte—and the difficulty in so regarding them depends partly on their suggested homology with the "chlamydospores" of the Endogonaceae and partly on the fact that they seem to be very rarely formed—the only other explanation that can be thought of is that they are vesicles parasitized by a Chytrid or some such organism. Peyronel was, however, alive to this possibility and decided against it.

Reproductive functions have not been attributed to the sporan-

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Legend to Text-figure 2.

Text-fig. 2. A. Five vesicles of *Rhizophagus* sp. from boundary of amorphous peat and glacial clay near Edmonton, Alberta. One is occluded by a basal plug. ×480. BBB. Four vesicles from same cluster showing proliferation. In these the original vesicle is occluded by a basal plug. ×480. C. Mature thick-walled hypha from same cluster with sub-dichotomous branching and no septa. ×480. D. Younger unseptate hyphae from same, one bearing a vesicle with thickened wall and no basal septum. ×480. E. Fragment of decaying root from peat overlying glacial clay near Edmonton. Mycelium with a *Rhizophagus* vesicle on surface and hyphae with two vesicles and five sporangiolar clusters in the cortex. ×255. F. Longitudinal section of cortex of *Abutilon* root, with hyphae and three vesicles, Kew. G. Part of a similar section more highly magnified, showing unseptate hyphae bearing two open-stalked vesicles. At one point a thin branching, rhizoid-like hypha has developed from a lateral knob near an anastomosis. H. Proliferation of a hypha through an empty vesicle of *Rhizophagus* from soil around *Abutilon* roots.

gioles. Gallaud and Peyronel call the arbuscules haustoria, and they have certain points of resemblance to these organs. Their function, however, is the reverse of that of haustoria. Miss McLennan (1926) showed by cytological and microchemical methods that the fat or oil which is a prominent feature of the reserve matter of the endophyte, as evinced by its extensive accumulation in the hyphae and vesicles in the early stages of the association of fungus and root, passes in the mycorrhizal endophyte of the darnel grass, *Lolium temulentum*, into the sporangioles in large quantity and, on their breaking down, is liberated into the cells, from which it is later removed presumably by being utilized by the grass. This was confirmed in the mycorrhiza of *Eriostemon Crowei* by McLuckie & Burges (1932) who suggest that in the early stages of the association the fungus acts mainly as a parasite but that later on the host plant gains the upper hand and receives nutritive material from the fungus. In the light of modern knowledge of nutrition it is not necessary to assume that this carbonaceous nutrient material comes from the soil, as Miss McLennan seems to suggest. It is, perhaps, more probable that the fungus manufactures from the carbohydrates of the root the fatty material which it later supplies to its host; one may even be tempted to suppose that it is not only the fat but some fat-soluble accessory substance manufactured by the fungus that is secured by the higher plant, with benefit to itself, when it "digests" the sporangioles. It seems unreasonable to suppose, as some have seemed to imply, that the fungus gains little from the root, since it gets most of its nourishment from the root cells and is out of reach of competition from soil-inhabiting organisms other than root parasites.

Attempts to grow the fungi

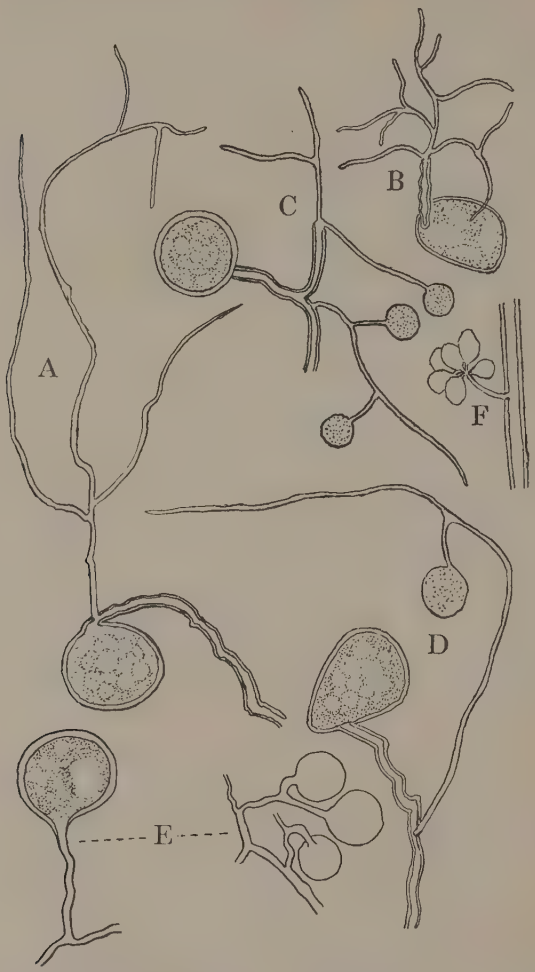
Fungi belonging to this group are amongst the commonest of soil fungi, and that they have not been recorded in the many lists of soil fungi that have been published is due to their failure to grow in artificial culture. Only Magrou (1937) has had a limited success in obtaining a mycelial growth that was unquestionably from the phycomycetoid endophyte of *Arum maculatum* and his cultures were mostly derived from the mycelium within the roots; hyphae which could be traced back to the intercellular hyphae in sections of *Arum* roots grew out to a maximum length of some 3 mm. and in one hanging drop transplanted on agar, grew to 5·6 mm. in length. The hyphae were unseptate, 3–10 μ or more in diameter, the thinner ones regular but the thicker irregular and sometimes branching into tangles. Some broad unbranched hyphae showed the characteristic angular projections at the sides. Anastomoses were frequent and sometimes occurred between the new hyphae and the original

mycelium between the root cells. On two occasions Magrou got a new growth from a thick-walled external hypha on a root, and once a long non-septate filament grew to the outside from a vesicle. Peyronel (1923–4) observed several indications of new growth from the ends of thick-walled old hyphae and also that relatively young vesicles may be penetrated by a mycelial filament forming a continuation of the bearing hypha. This proliferating hypha formed spiral coils which sometimes more or less filled the cavity. A similar example is figured in Text-fig. 2H. Figures have also been published by Bergamaschi (1932) and Ridler (1923) which indicate that vesicles in direct contact with a root or rhizoid can put out a germ tube which penetrates immediately into the host tissues.

My own attempts to grow this fungus have been confined to the external mycelium and vesicles, and though fine, hyaline, new hyphae were sometimes obtained, they did not grow extensively. The new growth was invariably obtained from the old thick-walled hyphae, either as a lateral outgrowth or from a broken end. Though several of these old hyphae were attached to mature vesicles, the vesicle itself was not observed to germinate. Text-fig. 3A shows the maximum growth obtained, the new hypha branching but remaining unseptate. In B the branching is more copious but the extension less. C and D show a development of small, round, thin-walled, terminal, spore-like bodies, which were probably an attempt to form vesicles but which did not progress beyond the stage shown. All these were from detached fragments of mycelium bearing vesicles in the earth around the roots of *Abutilon* hybrids extensively infected with the endophyte.

Systematic position and nomenclature of the fungi

As might be anticipated, there have been considerable differences of opinion regarding the identity of this group of fungi. Treub's (1884–90) early view (subsequently withdrawn) that the fungus in *Lycopodium* prothalli might be a *Pythium*, like that to which, as already mentioned, he believed the sugar-cane endophyte belonged, was followed by Bruchmann (1885) and Goebel (1888). It is, however, still doubtful whether the fungi in these prothalli are closely related to those in question here, and for some time it was thought that they might be Nectriaceae. The endophytes of the flowering plants in this group have been referred to *Mucor*, *Protomyces*, and several other genera. Halket (1930) emphasizes the septation of the mycelium in the fossil form she examined and states that it is the first typically septate fungus to be described from the British Palaeozoic rocks, differing in this character also from the phycomycetoid form of modern plants as usually described. Dangeard (1896, 1900) referred the poplar root endophyte to the Chytridiaceae. Though most writers have



Text-fig. 3. A. New growth laterally from an old hypha with a vesicle of *Rhizophagus* sp. from soil around *Abutilon* roots. The vesicle contains large oil drops. B. Similar growth from broken end of an old hypha with a vesicle of same. C. Two new hyphae, from broken end and from side, of an old hypha with a vesicle of same. The new growth bears three terminal thin-walled (?) vesicles. D. New hypha with (?) vesicle from an old hypha which bears a vesicle of same. E. Extramatrical vesicles of Wakker & Went's "Wortelschimmel No. 1", from the soil around sugar-cane roots. × 157. (Copied somewhat diagrammatically from Wakker & Went, 1898, Pl. XXII, figs. 4, 7.) F. Sporangioles of *Rhizophagus* sp. in cortex of root of *Ophioglossum vulgatum*, Kew.

stressed the Phycomycete-like characters of the group, Mostafa (1938) claims to have isolated and grown in culture a sterile septate fungus from the endotrophic mycorrhiza of *Tropaeolum majus*, with which he was able to synthesize the mycorrhiza. This fungus he refers to the *Mycelia sterilia*. From its characters it is difficult to feel confident that it belongs to the group here in question.

The group of endophytes examined by Peyronel (1923–4), excluding those of the orchids and other *Rhizoctonia* forms, of the Ericaceae and of Cryptogams, are considered by him to have definite points of resemblance to the Phycomycetes. Whether several allied species can be distinguished, as Gallaud (1905) seemed to hold, or whether all the forms can be included in a single species with biological races, he was not prepared to say; a plurality of species would seem to be indicated by the wide distribution of these endophytes in a great number of plants in temperate and tropical climates. A relationship to the genus *Endogone* and, in mycelial characters, to the Mortierellaceae is believed by Peyronel to be the most likely direction in which to seek for the affinities of the vesicular-arbuscular endophytes. He suggests that the latter and the genus *Endogone* may have arisen from a primitive type of fungus and that this type may be one from which have been derived the two divergent series of the Phycomycetes and the Mycomycetes.

In two later papers Peyronel (1924, 1937) claims to have established an organic connexion between the fruit bodies of *Endogone* and the endophytes of the phycomycetoid type in the roots of certain plants growing in the alpine Valli Valdesi. Sometimes, when the *Endogone* fructification occurred at or close to the base of the plant whose roots were involved, it was possible to follow the course of large hyphae from the fructification to the mycorrhiza. *Endogone vesiculifera* was thus associated with *Viola palustris* and probably with species of *Epilobium*, *Potentilla tormentilla* and *Caltha palustris*; *Endogone fuegiana* with *Viola palustris*, *Imperatoria ostruthium* and *Peucedanum verticillare*; and an unidentified species with *Euphorbia dulcis*. Three other plants were observed in mycorrhizal association with other undetermined species of *Endogone*. These fungi form, inside and outside the roots with which they are associated, isolated vesicles in addition to those formed in the fruit bodies. Few details are given of the methods by which the difficulties of establishing an organic connexion between the fructification of these fungi and the endophytic mycelium were surmounted and completer proof, especially by the synthesis of the mycorrhiza as has been done with ectotrophic forms and those of the orchids and Ericaceae, is much to be desired.

The systematic position of the Endogonaceae has only recently been established. The studies of Bucholtz (1912) and Thaxter (1922) showed that the perfect fructification of all the species in which it

has been found is a zygospore. Thaxter found in a single species, *Endogone fasciculata*, such a close association of the so-called chlamydospores and the zygospores as to furnish "the first indubitable evidence that the zygosporic and chlamydosporic types have been rightly included in a single genus". Later Miss Kanouse (1936) produced chlamydospores, sporangia and zygospores in cultures of *E. sphagnophila*, following the complete life cycle from a single sporangiophore. This work confirms the views of most of the earlier students of the group that its systematic position is amongst the Mucorales.

The characters which relate the vesicular-arbuscular endophytes to *Endogone* are confined to the hyphae and "chlamydospores" or vesicles. The hyphae of *Endogone* are somewhat characteristic. Thaxter (1922) describes those of *E. fulva* as being "rather stout, 8–12 μ in diameter, more or less, often nodulose or irregular, showing occasional septa". The extramatrical hyphae of the endophytes are similar, the irregular septation being particularly noticeable. Shibata (1902) and Reed & Frémont (1935) state that the walls of the endophytic mycelium contain chitin, a characteristic of the Zygomycetes alone amongst the Phycomycetes. The degree of septation varies in the different species of *Endogone*. In *E. arenaceae* the hyphae are stated by Thaxter to be very rarely septate, in *Sclerocystis Dussii* the basal hyphae from which the sporocarp develops are unseptate but the outer envelope is formed from large septate hyphae, and in *Glaziella* there also appear to be two sets of hyphal elements, one concerned in sporulation and unseptate, the other sterile and copiously septate. Miss Walker (1923), who appears to have been the first to have grown a member of the Endogonaceae in culture, found that in *Modicella malleola* (*Endogone malleola* Hark.) the young hyphae were unseptate and that the septa formed later cut off either empty from full segments or moniliform cells which developed in masses in some of her cultures from sporangiospores and from the interior of the sporangiocarp. The stroma of the latter, however, is composed of closely septate hyphae. She did not consider (rightly as Miss Kanouse's (1936) work shows) that this septation is sufficient to tell against the relationship of *Endogone* to the Mucorales, and stresses the similarity of *Modicella malleola* to *Mortierella*. In Miss Kanouse's cultures of *Endogone sphagnophila* and *E. occidentalis*, septa were sparingly formed in places other than in connexion with the reproductive organs, the protoplasm of the hyphae and chlamydospores contained numerous conspicuous oil drops and the outer wall of the chlamydospore was continuous with the wall of its stalk, separation of the contents of the chlamydospore from the bearing hypha being effected by a tardily formed inner wall, staining differently from the outer wall. It was not easy to demonstrate the presence of two walls in all spores.

As regards the relationship of the so-called chlamydospores of the

Endogonaceae to the vesicles of the mycorrhizal endophytes the first noticeable point is their size. Those of *E. tenebrosa* are up to 275 × 260 μ and are readily visible with the naked eye; those of *Glaziella vesiculosa* are even bigger, up to 415 × 380 μ according to Thaxter (1922). These are amongst the largest sizes for thick-walled, unicellular chlamydospore-like bodies recorded in the fungi and recall the "resting spores" of some of Kidston and Lang's fossil fungi mentioned earlier in this paper. Several of the species have "spores" exceeding 100 μ in diameter, paralleling the vesicles of the existing endophytes. Next, there is the usually open protoplasmic connexion between the "spore" and its stalk. In a few species, as *Endogone fulva*, *E. pulvinata* and *Sclerocystis Dussii*, the chlamydospore is early closed off from its stalk by a distinct septum but in most of the other species an open channel remains, though it may become very narrow owing to progressive thickening of the neck end of the stalk. The presence in the mature chlamydospore of a distinct exospore and endospore is mentioned in the two species studied by Miss Kanouse, and Thaxter also found two walls in several species, but in others a double covering was not evident though the thick (8 μ in *Endogone borealis*, 15–20 μ in *E. tenebrosa*, only 2–4 μ in *E. fulva*) and coloured membrane, often brown or red-brown, would tend to mask a double covering if one of the two were thin. In the vesicles of the endophytes an inner wall is often formed in the mature condition and may sometimes become separated from the outer wall and retracted from the latter, so as to resemble an oospore lying in an oogonium. Finally, the contents of the chlamydospores of *Endogone* are often marked by the presence of multiple oil or fat droplets, the heavy accumulation of oil being especially mentioned by Miss Kanouse.

In all these characteristics the Endogonaceae show more closely than any other fungi known to me resemblances with the vesicle-bearing mycelium of the endophytes which I have examined, and they support Peyronel's views as to the systematic position of the latter. The resemblance is, as one would expect, closest in the chlamydosporic members of the genus *Endogone*. How close this is can be judged from the illustration of *E. macrocarpa* in the Tulasnes' *Fungi Hypogaei*, 1851, Pl. XX (reproduced in Engler's *Pflanzenfamilien*, I, 1, 148, fig. 131; Rabenhorst's *Kryptogamen-Flora*, V, 121; and (in part) Lindau's *Kryptogamenflora der Mark Brandenburg*, VII, 5). This shows the sub-dichotomous branching of irregular hyphae and the thick-walled chlamydospores, very variable in size in this species according to Thaxter (1922) but reaching sometimes a maximum length of 230 μ and a maximum breadth of 180 μ. The open communication of these "spores" with their stalk is clearly visible.

While, therefore, admitting that the proof is not yet fully furnished, pending further details of Peyronel's work, I regard the group of

fungi under consideration as probably belonging to species of the Endogonaceae which, often, have lost the power of forming the compound fructifications common to the family. If so, and if the relationships of the present day endophytes to those of Early Devonian and Carboniferous formations mentioned above are accepted, the family is a fairly ancient one. There is not, however, as yet any reason for regarding it as so ancient as to give plausibility to Peyronel's hypothesis that it may be the common ancestor of the Phycomycetes and Mycomycetes. The features which it has in common with these two divisions of the fungi, such as the irregular septation of the hyphae, are shared by other fungi like some of the Mucoraceae and can be equally considered to mark transitional stages between the Phycomycetes and the higher fungi.

Dangeard's (1900) account and figures of *Rhizophagus populinus*, a new genus and species formed by him in 1896 to define the endophyte as it occurs in poplars, leave no room for doubt that he was dealing with a typical member of the group. Dangeard regarded the fungus as a member of the Chytridiaceae and the cause of a serious disease, but Petri (1918–19) rightly indicated its true nature. Nevertheless, however unfortunate the name may be, having regard to the mutualistic character of the association, *Rhizophagus* appears to be the first legitimate name given to the present-day endophytes of the vesicular-arbuscular type in their imperfect condition as "chlamydospore"-bearing fungi, probably imperfect forms of Endogonaceae.*

R. populinus, as described by Dangeard, has an intracellular mycelium of unseptate large hyphae restricted to the root layers external to the endodermis, often closely applied to the cell wall, terminating sometimes in large, more or less spherical ampullae and also giving off laterally towards the interior of the host cell a stalked cluster or brush of fine branches which clasp the protoplasm and nucleus of each cell in a multiplicity of extremely fine terminations. These are regarded as comparable to the haustoria of the Peronosporaceae and are so characteristic as of themselves to justify, in Dangeard's opinion, the creation of a new genus. The ampullae are regarded as sporangia, though zoospores or any other form of germination were not seen. They may contain up to five or six hundred nuclei and a dense protoplasm. Many spherical, very thick-walled cysts were also found on the same mycelium and were regarded as a resting stage of the fungus, especially as they contained an abundance of

* It would have been tempting to apply Naegeli's (1843) original name *Schinzia* to these fungi, were it not that he restricts its use to a portion of the fungi found by him in *Iris* roots that have little similarity to the mycorrhizal fungus; his description and figures of the unnamed "Champignon filiforme" in the same roots suggest a distribution and morphology more closely resembling the endophyte. Later fungi referred to *Schinzia* are not related to Naegeli's organisms.

oil. The excellent figures given by the author show quite typical arbuscules surrounded by a dense mass presumably of sporangioles in process of digestion, and large thin- and thick-walled vesicles, the former clearly unprovided with a basal septum. Sub-dichotomous branching and hyphal anastomosis are shown and in one place the irregular knee-like angularity so commonly found in the hyphae of these endophytes can be seen.

Based on this description, the genus *Rhizophagus* is defined in Saccardo's *Sylloge Fungorum*, XXI (1912), 847–8, as having a mycelium of continuous branched intracellular hyphae forming here and there fascicles of rhizoids; vesicles (zoosporangia of Dangeard) irregularly globose or clavate, many nucleate; resting spores intercalary or terminal, globose, with a smooth wall and numerous droplets. F. v. Minden (*Kryptogamenflora der Mark Brandenburg*, v, 1, 421) gives a fuller diagnosis, mentioning the longitudinal extension of the hyphae in the roots and the presence of fat in the resting spores, and suggests that the genus may belong to the Peronosporeae. In both, the essential characters are the vesicles and arbuscules and the only additions required to cover the phycomycetoid endophytes are to enlarge the diagnosis to include extra- as well as intramatrical mycelium, inter- as well as intracellular hyphae, tendency to sub-dichotomous branching, vesicles in open communication with their stalks, and the frequent change with age and exposure of the hyphal and vesicular wall from colourless to yellow.

Rhizophagus thus defined to include the vesicular-arbuscular phycomycetoid endophytes may most satisfactorily be regarded as an imperfect genus of the Endogonaceae with at present only the named species *R. populinus* Dang., *R. Theae* (Zimm.) n.comb. (syn. *Protomyces Theae* Zimmermann (1901)), and *R. Marattiacearum* (West) n.comb. (syn. *Stigeosporium Marattiacearum* West (1916)). In spite of the presence of the curious chlamydospores described in this last species, it is scarcely possible to regard it as characteristic of a separate genus.

Discussion

It will be evident from the above account that the roots of most flowering plants and ferns, and the prothalli of the liverworts amongst the Bryophyta and of some of the Pteridophyta, are subject to invasion by fungi belonging, with few exceptions, to a homogeneous type characterized by the possession of special organs, the vesicles and sporangioles. These fungi are not found in all roots and appear to be rare in many plants in particular localities. The evidence from cotton and the cereals shows, however, that absence or rarity of the fungus in one place is not inconsistent with prevalence in the same plant elsewhere. The association is, to a certain extent, casual, as has

also been pointed out by Miss Ridler (1923) in *Lunularia*, but it need not on that account be without significance to either or both the partners in the association. Indeed the elaborate mechanism for the manufacture of fatty substances and their rendering to the higher plant can scarcely have no significance. With this mechanism must be associated the peculiarities of the special organs of the endophytes in question. The vesicles are constructed so as to store considerable volumes of an oily substance free to be resorbed back into the mycelium without the intervention of a septum to block the passage, and these stores of oil or fat are emptied into the root cells from the sporangioles. The latter are so designed as to offer the maximum of surface to the disintegrating action of the cell juices. They are not merely artifacts due to a "digestive" action of the cell on the fine branches of the arbuscules as appears to be suggested by some observers, but are definite bladders formed at the tips of these branches and passing through a stage of turgidity before they break down. Nor are they haustoria engaged in absorbing nutriment from the host cells as has also been suggested, for their formation often marks the end of the vegetative activity of the fungus in a particular region, or in a considerable area of fine roots simultaneously. That they have some function in the developmental nutrition of the higher plant, as most students of them have suggested, can hardly be doubted. The purely tentative hypothesis is advanced that this is not the supply of fat as such but of some fat-soluble growth or development promoting accessory substance. The extraction of sufficient quantities of this hypothetical substance would present great difficulties so long as the endophyte defies artificial cultivation; but in certain plants such as bamboos or *Ricinus communis*, the volume of the endophyte may be very considerable in the white roots and it might be possible to obtain appreciable quantities of the fungus from them at an appropriate season.

Summary

An account is given of the distribution and morphological characters of the endophytes of plant roots and of some prothalli belonging to the vesicular-arbuscular or phycomycetoid type of mycorrhizal fungi.

The characteristic organs of these fungi, the vesicles and the arbuscular-sporangiolar apparatus, are regarded as being mainly concerned with the accumulation of fatty material (possibly with accessory nutrients) and its transference to the higher plant.

The common occurrence of this group of fungi in cultivated and probably in other soils is stressed and they are considered to be able to form mycorrhizal associations with most plants.

The close relationship of the fungi concerned to the Endogonaceae

is pointed out and Peyronel's view that they are to be considered as members of this family is thought to be probably correct.

The generic name *Rhizophagus* is considered to be the first legitimate name applied to a member of the group, which is thought to consist of a number of allied species in this genus.

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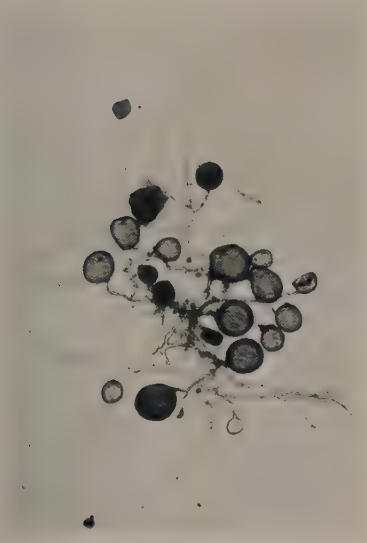

Fig. 1

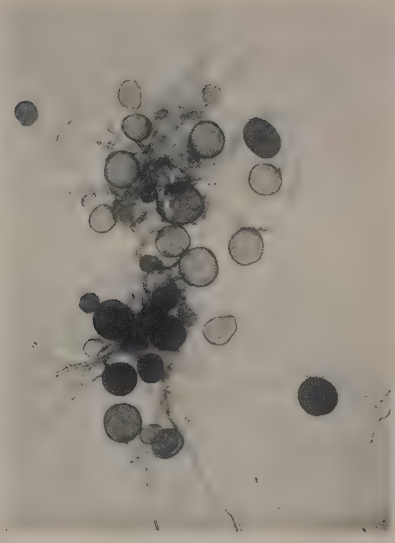

Fig. 2

Fig. 3

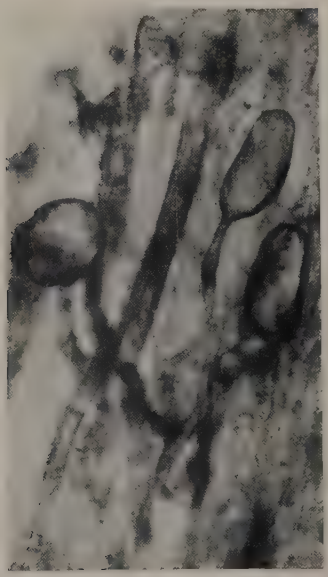

Fig. 4

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EXPLANATION OF PLATE XX

Figs. 1, 2. Extramatrical mycelium and vesicles of *Rhizophagus* sp. found around a sample of cotton roots sent by Mr R. E. Massey from the Sudan in 1934.
Fig. 3. *Palaeomyces Asteroxyli*. Fine hyphae dilating into oval vesicles. ×250. From Kidston & Lang's untouched photograph (1898, Pl. II, fig. 23).
Fig. 4. "Fungus No. 6". Hyphae bearing oval and spherical vesicles from a partially decayed stem of *Rhynia major*. ×250. From Kidston & Lang's untouched photograph (1898, Pl. II, fig. 19).

(Figs. 3 and 4 reproduced by kind permission of Prof. Lang and of the Royal Society of Edinburgh.)

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SOME OBSERVATIONS ON *SAPPINIA PEDATA* DANG.

By W. R. IVIMEY COOK, B.Sc., Ph.D., F.L.S.
University College, Cardiff, Wales

Despite the amount of work which has been done upon coprophilous fungi, very few records of species of the Acrasiales have been made among the many fungi found growing upon dung. It was therefore surprising to find in 1933 that *Sappinia pedata* occurred quite frequently in cultures of cow dung obtained from the Botanical Gardens of the University of Bristol. Here *S. pedata* occurred after about three days when the dung was kept at about 18° C. At this temperature, however, various moulds also grew rapidly and soon swamped the dung; when the cultures were moved to a cold greenhouse at a temperature of 6–8° C. *S. pedata* flourished for some time until finally smothered by other fungi. Considerable quantities of the organism were obtained and an attempt was made to study the life-history and compare the results with those previously published. The organism was again isolated from cow dung collected at Dinas Powis, Glamorgan, in 1935, but has not been found again since.

Only two important contributions seem to have been made towards a study of this organism. The first is that of Dangeard (1896) who published a description of the organism in a short paper devoted to the Acrasiales; the second occurs in Olive's monograph (1902) of the American species. So far as can be ascertained, this organism has not been previously recorded in Great Britain.

Probably, as Olive suggested, *S. pedata* is not closely allied to the other species of the Acrasiales, but forms a connecting link between the Acrasiales and the true Amoebae. Yet, in certain features, it does show affinities with the former group and, for the time being, it is more convenient to retain it within the Acrasiales.

When first seen, *S. pedata* appears as a watery white glistening mass, standing out from the surface of the dung and giving the appearance of stalked sporangia about 0·5 mm. in length and about 0·1 mm. in diameter. The microscope shows that these stalks are short pieces of grass or other vegetable matter appertaining to the dung, and the swollen ends consist of masses of amoebae closely associated to form club-shaped groups at the ends of the stalks. When seen dry these masses have a yellowish white glistening appearance and seem to

be homogeneous. Immediately water is applied, the whole aggregation becomes disorganized, and the individual amoebae separate, leaving the stalk behind.

The individual amoebae have an extremely irregular outline, being folded and toothed, and looking like cells which have been strongly plasmolysed. After a few minutes under a cover glass, the cells gradually assume a more regular shape and become roughly oval. They move by means of blunt pseudopodia, showing a sluggish flowing movement. The amoebae migrate towards one another and as soon as a few have become associated they form centres to which more and more will migrate and join up. In this way a pseudoplasmodium is formed.

The structure of the pseudoplasmodium is interesting. The amoebae which compose it retain their individuality and, although associated together, continue to feed and grow independently. So long as they are supplied with nutriment and oxygen the members remain attached, but the least change in conditions, such as brilliant illumination, or slight pressure of a cover-slip on a preparation, caused by the liquid beginning to dry up, induces the amoebae to become spherical and lose contact with one another. If more drastic treatment is applied, such as the drying up of a culture or the deprivation of food, the pseudoplasmodium breaks down completely and the individuals separate widely. In a little time such cells become spherical and enclosed in a thin membrane, which is retained until fresh water and food is given them. These encysted amoebae are regarded as equivalent to the spores of other species of Acrasiales, though it would appear that the two are scarcely homologous. The encysted amoebae measure 51-55 μ in diameter, while the active amoebae are 58·5–70·4 μ by 23·9–37·2 μ, which is large compared with the other species of Acrasiales.

The internal structure of the cell shows certain points of interest. The most striking feature is the contractile vacuole; one to three may be present in the same amoeba, either associated or scattered in the cell. They contract and discharge rapidly when the amoeba is active, each taking about five minutes to discharge and fill again. When full, they measure about 7 μ in diameter. The cytoplasm is divisible into two areas, a very fine granular peripheral ectoplasm and a much coarser, denser central endoplasm. The endoplasm contains the food, which consists mainly of bacteria, though occasionally tiny green flagellates are also taken in. These latter, however, do not appear to be digested and are subsequently disgorged. In resting amoebae, or those which have just become encysted, the endoplasm occupies the greater part of the cell, the ectoplasm only forming a thin peripheral layer. Bacteria are ingested by the pseudopodia flowing around and engulfing them, but it seems probable that

additional solutes are also absorbed from the dung. This is probably true specially of pseudoplasmodia where no pseudopodial activity occurs although the contractile vacuoles are working rapidly.

It was found possible, after a pseudoplasmodium had become accustomed to confinement under a cover glass, to introduce a solution of methylene blue, allow it to act for about five minutes, and then wash out the excess with dung decoction without killing or disorganizing the pseudoplasmodium. Subsequently with care it was possible to keep the pseudoplasmodium alive for some days—once for nine—by supplying it with dung decoction at intervals, and keeping it in a damp chamber. It was then possible to study the behaviour of the component cells and in particular the division of the nuclei.

Immediately after the introduction of the methylene blue a curious effect, giving the appearance of irregular strands across the cell, was produced, but this disappeared within twelve hours. I am unable to explain this appearance but suggest that it may be in some way connected with the ingestion of food. Later the staining became more even, and deeply stained parts were found surrounding the nuclei, which made their study more difficult.

All the amoebae are binucleate throughout life, both nuclei being of the same size and closely associated. Each nucleus consists of a nuclear membrane enclosing a darkly staining nucleolus separated from the periphery by a colourless area. The nuclei are small, measuring 4μ in diameter. The two nuclei divide simultaneously prior to the division of the amoeba, so that for a time four nuclei may be found in a single cell. Only two stages in the division could be made out, but these suggest that a typical mitosis does not take place. The nuclear membrane persists throughout the division, and the nucleolus, instead of disappearing, becomes drawn out and finally separates into two parts. There were no indications of any spindle fibres, though these might not have stained sufficiently to be observed through the deeply stained endoplasm. The chromatin first appears as a band across the nucleolus after which it presumably splits. The second stage observed was where the nucleolus had become elongated and the chromatin, after splitting had migrated towards the ends of the nucleolus. The two nuclei within the amoeba go through the same stages of division at the same time. After division is completed, the pairs of nuclei separate in such a way that one half of one original nucleus becomes associated with one half of the other. The nuclei then migrate to the opposite ends of the amoeba which has become drawn out during the nuclear division. Meanwhile the amoeba begins to invaginate until finally it is cut in two. It takes about twelve hours for an amoeba to divide from the time when nuclear division is first observed to the complete division of the amoeba,

but possibly in natural conditions the process is speeded up because of the greater supply of food.

After a time pseudoplasmodia which were stained in the methylene blue became paler and it seems likely that the stain is gradually got rid of by the organism, which eventually would become completely free from it. These partly destained amoebae were found to be most suitable for studying stages in nuclear division. All attempts to get the organism into pure culture failed.

Discussion

Our knowledge of the distribution of the Acrasiales is not extensive, but it is probable that *S. pedata* is not uncommon in this country although this appears to be the first record of its occurrence. The British form differs from that found in France and America in the absence of pedicillate amoebae which grow singly from the stalk. I agree with Olive (1902) that the organism is most common on fairly fresh dung, especially on dung which has not been dropped more than a few hours. It does not appear in culture on fresh dung for some little time, nor has it been found among moulds on dung. Dangeard (1896), on the other hand, found his material on old dung cultures which had dried up. Olive considers that there are, in America, two species differing in the size of the spores and of the pedicillate amoebae. The British form agrees most closely with the larger of the American ones.

The cytology of the organism differs markedly from that of other species of Acrasiales. The binucleate condition does not occur in any of the other species, though it is interesting to note that Cienkowski (1873) described, but apparently did not name, two kinds of amoebae on dung, probably closely allied to *S. pedata*, which had two nuclei in their cells. Dangeard noticed that some of the cells of *S. pedata* were binucleated, but thought that these represented a stage in nuclear division, and the same view was taken by Olive.

Binucleate amoebae are met with in other groups; for example in *Amoeba binucleata* and in certain species of *Arcella*, so that the condition found here is by no means exceptional among primitive organisms. In fact one may regard it as a condition where the nuclear divisions are maintained one ahead of the cell divisions. The actual details of the division in *Sappinia pedata* are difficult to follow, but there is little doubt that they differ considerably from those found by Olive in other genera. So far as can be observed, separate chromosomes are not differentiated though it is possible that more critical staining might reveal them. In the persistence of the nuclear membrane and nucleolus the division in *S. pedata* agrees closely with that described by Chatton (1910) *in Amoeba mucicola*.

It differs, apparently, in the absence of any spindle fibres. It also agrees in general with the type of nuclear division found in the Plasmodiophorales, and differs from that found in the Mycetozoa, thus suggesting possibly that the Acrasiales may be more closely allied to the Plasmodiophorales than to the Mycetozoa. It must be remembered, however, that the normal binuclearity of the cells differs from anything found in either of these groups and also that *Sappinia pedata* cannot be regarded as a typical member of the Acrasiales, so that phylogenetic considerations based upon this organism are not of any great value.

Summary

1. *Sappinia pedata*, a primitive member of the Acrasiales, has been obtained for the first time in Great Britain. It was grown on cow dung collected in the Botanical Gardens of the University of Bristol, and from Dinas Powis, Glamorgan.

2. The life history has been followed and both the "heaping up" stage and the pseudoplasmodium have been studied. Pedicillate amoebae have not been found in the British form.

3. With the aid of methylene blue the amoebae have been stained without killing them and by this means a study of the nuclear division has been made.

4. The amoebae are binucleate. Both nuclei divide simultaneously and in the same way. During division separated chromosomes are not apparently differentiated and the nuclear membrane and nucleolus persist.

5. After nuclear division, paired nuclei migrate, each pair being made up of half of each of the original pair. The amoebae elongate and divide by constriction.

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PROCEEDINGS

Meeting held at University College, London, 20 November 1937.

The President, Mr K. St G. Cartwright, in the Chair

H. E. Croxall. The British Species of the Genus *Diatrypella* Ces. & de Not.

In the perithecial stage, *D. quercina* (Pers.) Nits. is readily distinguished from the other species. *D. favacea* (Fr.) Ces. & de Not., *D. verrucaeformis* (Ehr.) Nits., *D. nigro-annulata* (Grev.) Nits., and *D. Tocciaeana* de Not. can be separated only by the small differences in the external appearance of the stromata on their respective hosts.

In cultures on agar or on wood each species produces two imperfect stages, a *Libertella*-stage and a *Naemospora*-stage. The *Libertella* spores of *D. quercina* differ from those of the other species.

Similar imperfect spores have been found in the field associated with perithecial stromata.

In culture, *D. quercina* forms typical perithecial stromata on its usual host, *Quercus*, and sometimes on other hosts. The other species develop equally well on any host except *Quercus*, the appearance of the stromata varying with the host wood and external conditions.

All stages in the life history of each species are formed in monospore cultures.

It is concluded that *D. quercina* and *D. favacea* are the only distinct British species.

Dr L. E. Hawker. Notes on some Further Work Concerning Growth and Sporulation of Certain Fungi.

A brief account was given of work relating to the production of growth substances by certain fungi and bacteria. Growth substances of two kinds are produced by fungi. The first of these (heteroauxin) increases the growth of the coleoptile of oat but has no significant effect on fungi. The second type of growth substance has no effect on higher plants but increases the growth and sporulation of certain fungi. The two can be separated on a number of chemical and physical properties. They differ in their distribution of coleoptile of oat.

The fungal growth-promoting substance is probably necessary for the sporulation of all fungi, but while some can synthesize it from a synthetic medium, others must obtain it from an external source. The production of perithecia by *Melanospora destruens* is largely conditioned by the interaction of three factors: (1) concentration of growth substance, (2) concentration of food substances, (3) concentration of toxic staling substances.

The conditions under which the growth substance is produced by *Rhizopus suinus* were briefly described.

Meeting held at University College, London, 29 January 1938.

The President, Miss K. Sampson, in the Chair.

DISEASES OF VEGETABLES

L. Ogilvie and C. J. Hickman. Vegetable Disease Investigations at Long Ashton.

The investigations on vegetable diseases carried out at the Long Ashton Research Station, near Bristol, date from 1930, and have been made possible by a grant from the Ministry of Agriculture for a special assistant. B. O. Mulligan and P. W. Brian have co-operated in the work in the past. The paper dealt with only a few of the more important diseases, full accounts on which will be found in Progress Reports published in the *Annual Reports* of the Research Station.

Halo blight of dwarf beans, caused by *Bacterium Medicaginis* (Sack.) E. F. Sm. var. *phaseolicola* (Burk.) Link & Hull, has been known in England since 1930. The symptoms are small water-soaked spots on the leaves surrounded by yellowish haloes, and, in systemic infection, a chlorotic appearance of the leaves accompanied sometimes by wilting and exudation of bacterial tendrils from the stem. Pods are distorted and covered with water-soaked spots from which bacteria exude like drops of candle-grease. Infected seeds have raised blisters paler than the rest of the seed coat. The wilt symptoms especially may induce severe losses. Rain splashes the bacteria from plant to plant. Control measures include rotation of crops, the use of reasonably clean seed, and early roguing of diseased plants. Seed should not be soaked before sowing. There is a striking difference between the resistance of the various groups of dwarf beans and resistance appears to be correlated with seed colour to some extent. The pods of most varieties appear to be almost equally susceptible.

Foot rot of dwarf beans, caused by *Fusarium Solani* (Mart.) App. & Wr. var. *Martii* (App. & Wr.) Wr. forma 3 Snyder, is prevalent in the Evesham district of Worcestershire. It had been known previously in many bean-growing countries. The fungus occurs in the soil and attacks the roots and the stem bases, turning them reddish brown. The leaves become chlorotic and only the first pods are fully formed. The disease is most severe in dry seasons when it may reduce the yield by half. Strong growing varieties, such as the Flageolet kinds, are more resistant since they throw out fresh stem roots at soil level. Individual vigorous plants occur in most commercial varieties.

A mosaic disease of dwarf beans, probably identical with the common bean mosaic of the United States, is prevalent in the south-west. The leaves are mottled and blistered with their edges curled downwards. The pods are distorted, roughened and covered with small warts or pimples, the so-called "hydrotic spots". Pod samples may be as much as 50 % infected. Varieties with dark green foliage appear to be more resistant.

Anthracnose of dwarf beans, caused by *Colletotrichum Lindemuthianum* (Sacc. & Magn.) Bri. & Cav., is prevalent here only during wet and cool summers. No investigations on strains of the fungus have been carried out in England, but the variety Princess appears to be immune here as it is in Germany.

Foot rot of peas, caused by *Fusarium Solani* (Mart.) App. & Wr. var. *Martii* (App. & Wr.) Wr. forma 2 Snyder, is apparently widespread throughout the country. It occurs in the United States and on the Continent, where it is a component of the pea disease complex known as St John's Disease. The symptoms are chocolate-brown streaks at the stem base, brown discoloration of the roots, and poor development of root nodules. Under high temperatures the vascular system may have a reddish discoloration. The lowest leaves begin to wither when the plants

are forming their first pods. Finally they die off in well-defined patches. The disease is favoured by heavy rainfall in early summer and by rather high temperatures. Varieties of peas with round seeds are usually more affected than those with wrinkled seeds. It has been found that applications of sulphate of ammonia reduce foot rot somewhat and enable greater yields to be obtained on infected soil.

Pea sickness. Peas affected with *Fusarium* foot rot are very often attacked at the same time by the eelworm *Heterodera Schachtii*. The disease symptoms are then intensified and the plants are dwarfed and yellow and also die off prematurely. Applications of sulphate of ammonia are of great value.

Pythium foot rot of peas. A distinct foot rot of peas has been recorded from Wiltshire. Large patches of plants die off, the bases of the stems being watersoaked and the leaves yellowish and wilted. The disease is due to *Pythium ultimum* Trow and appears to be identical with one which is prevalent in New York State. It is well known in Wiltshire that adequate rotation is essential for a healthy pea crop.

Leaf and pod spots of peas, caused by *Ascochyta Pisi* Lib. and *Mycosphaerella pinodes* (Berk. & Blox.) Niessl, are common in the south-west in wet seasons. Both fungi are seed-borne, the former causing a seedling blight, in which the seedling is greatly checked by the development of sunken lesions on stem and leaves, and the latter a severe foot rot. The use of organic mercury dusts as seed dressings prevents development of the disease on the seedlings to a large extent.

Pea-seed dressings. The use of cuprous oxide as a seed dressing for peas was evolved in the United States by Horsfall. Under English conditions pre-emergence damping off has been greatly reduced in autumn and early spring sown peas by this dressing, and emergence has been increased two or three times. As with organic mercury seed dressings, little improvement is evident from the use of these dressings after March.

A mosaic disease of lettuces has recently been under observation. It is characterized by a mottling or chlorosis of the leaves accompanied by poor hearting. The disease is most severe in mild winters on winter lettuces grown entirely outside. Whole fields may be rendered worthless. There is a considerable difference in the intensity of symptom expression in different groups of lettuces, some being so little affected as to form marketable hearts. The disease can be largely avoided by growing the plants in frames and planting out in spring.

Botrytis disease of lettuces, caused by *Botrytis cinerea* Pers., is prevalent on lettuces wintered out of doors in the south-west and is related to the winter hardiness or otherwise of the variety or group in question.

Mint rust. Mint is largely grown in the Cheltenham district, the rhizomes being lifted and forced in glasshouses during the winter. The forced shoots are often swollen and distorted owing to infection with the rust *Puccinia Menthae* Pers. *Mentha villosa-nervata*, the species most favoured, and *M. spicata*, which is grown in the north of England, are both highly susceptible. The rust may be prevented entirely by dipping the rhizomes in water at 105–115° F. for ten minutes. This kills teleutospores which are lodged between bud scales and are responsible for the aecidial infection.

D. L. G. Davies. Some *Fusarium* Diseases of Vegetables.

Fusarium *wilt of runner beans.* A wilt of runner beans (*Phaseolus multiflorus*) caused by a *Fusarium* was reported for the first time in England by Ogilvie in 1931. It occurs in Worcestershire, mainly in the Severn Valley near Kempsey, where runner beans are extensively grown.

The symptoms are mainly a rolling inwards of the leaf margins, followed by wilting of part or the whole of the plant. A dark brown discoloration of the vascular system is usually clearly evident at the base of the plant and often traceable up into the youngest leaves and pod stems and down into the main and lateral roots.

The causative fungus has been studied culturally and has been identified by Dr H. W. Wollenweber as *Fusarium vasinfectum* Atk. var. *lutulatum* (Sherb.) Wr. This is the first record of this species in Great Britain.

The fungus is confined to the vascular elements, and is often accompanied by a gum-like substance. It has not been isolated from pods or seeds and is apparently not seed-borne.

Inoculations of the "foot" of healthy plants with the fungus have produced the typical wilt symptoms.

The optimum temperature for growth is 26–28° C.

A field trial carried out by Ogilvie in 1933 indicated that several varieties are more resistant than others. Among these are Giant Painted Lady, Czar and Sutton's Scarlet.

A Fusarium *disease of leeks.* A *Fusarium* disease of leeks was reported by Ogilvie from the Evesham district of Worcestershire in 1932. Diseased plants obtained in 1937 showed a complete collapse of the leaves, which had a bleached appearance or were coloured red at their bases. Abundant pink spore masses were produced.

The fungus was isolated and identified as *Fusarium culmorum* (W. G. Smith) Sacc. The typical symptoms were reproduced on inoculation.

Foot rot of pea seedlings. The foot rot of peas caused by *Fusarium Solani* (Mart.) App. & Wr. var. *Martii* (App. & Wr.) Wr. forma 2 Snyder has already been described. No seedling rot caused by this fungus has been recorded here in the field, although it is known to occur in the United States.

Seedlings grown in artificially infected soil in the greenhouse at a high temperature developed a rotting of the cotyledons, a foot rot, and sometimes a wilt.

W. Brown, M.A., D.Sc., F.R.S. *Botrytis* Disease of Frame Lettuce.

Survey work carried out in Middlesex over the years 1929–31 showed that *Botrytis cinerea* attacks lettuce plants at all times of year, both under glass and out of doors, and that the losses incurred may be especially severe in seedlings overwintered in cold frames. When the time for transplanting arrives (February–March) there may be serious blanks in the frames, but a more important aspect of the trouble is that, after the apparently sound plants have been set out in the field, further losses may occur. These may amount to one-half to three-quarters of the crop. The grower has therefore to replant a proportion of the field area, sometimes more than once. Over and above the extra labour involved, all such replantings mean a retardation of the date of maturity, and since the aim of the method of cultivation is to produce a crop which will head out some weeks earlier than would lettuce sown in the open in spring, a loss in market value results, even if a reasonably good stand of plants is finally obtained.

From a study of experimental sowings at Slough over the past eight years the following conclusions have been drawn:

(1) The primary stage of the trouble is damping-off, due to a species of *Pythium* and to *Rhizoctonia Solani*. The latter is the important fungus as it is liable to spread during the winter months (November onwards), with the result that areas of dead seedlings are produced.

(2) Invasion by *Botrytis* typically develops over the period January–March, by which time the seedlings should be producing a thick stand of plants. The cotyledons and lower leaves are thus liable to be shaded. They turn yellow or even wither off, and therefore become highly susceptible to *Botrytis* attack. On this account the disease is accentuated by early sowing in the autumn.

(3) All dead leaves and plants become densely covered with *Botrytis* spores, so that all plants, whether healthy or not, are abundantly contaminated with spores.

(4) Susceptibility of lettuce seedlings to *Botrytis* is increased by soil wetness and coldness and by the act of transplanting.

An effective control of this trouble has been obtained by use of a dust containing pentachloronitrobenzene as active principle. An application to the soil surface, immediately after sowing, largely prevents damping-off. After that, treatment is

given according to need, and in general no further dustings are required until January. It is undesirable to apply the treatment while the seedlings are very small, if a visible check is to be avoided. During February and March, several dustings may be given, the last of these, which should be very thorough, being given immediately before transplanting. The several dustings ensure that any lettuce débris in the frames does not incubate a crop of spores, that a complete stand of plants is obtained in the frames, and that the seedlings are free from *Botrytis* contamination or infection at the time of transplanting.

G. C. Ainsworth and Enid Oyler. Some Experiments on the Spotting of Tomato Fruit by *Botrytis*.

Both field and greenhouse-grown tomatoes are frequently disfigured by spots, consisting of a minute brown central puncture surrounded by a pale yellow or silver coloured ring, which Read (*Rep. Exp. Res. Sta. Cheshunt*, 1936, pp. 64–9, 1937) showed to be caused by *Botrytis cinerea*. The spots arise under conditions of high humidity which allows a *Botrytis* spore lying on the fruit surface to germinate, and the germ tube penetrates the epidermis. With the return of drier conditions the sporeling dies but the pectinase enzyme secreted by the germ tube diffuses outwards from the puncture and by dissolving the middle lamella between the cells gives rise to the ring.

Experiments to examine the influence of various factors on spotting showed that small fruit were more susceptible than larger fruit in which the walls of the epidermal cells are thickened, that there is a slight difference in varietal susceptibility and that turgid fruit are more susceptible than fruits not fully turgid. A film of moisture on the fruit was shown to be an essential requisite for spotting which was found to occur when optimum conditions prevailed for as short a period as four hours. Similar spots were produced by means of other species of *Botrytis* (*B. Allii*, *B. Tulipae*, and *B. Fabae*), although these species were not capable of causing a soft rot of green tomato fruit, and attempts were made to reproduce the spots by means of the enzyme prepared from germ tubes of *Botrytis*.

Meeting held at University College, London, 19 March 1938.

The President Miss K. Sampson, in the Chair.

Dr J. H. Western. The Histology of Resistance to Oat Smuts.

The invasion of certain varieties of oats by five physiologic races of *Ustilago Avenae* (Pers.) Jens. and *U. Kolleri* Wille was described, with special reference to the behaviour of the mycelium in those resistant oats which show no external evidence of infection. In the host-pathogen relationships discussed, resistance was expressed in three principal ways, namely (1) failure of initial penetration through the development of a papilla from the epidermal cell wall (e.g. two races of smut on the variety Markton), (2) Necrosis of host cells and subsequent degeneration of the parasitic hyphae after initial penetration had been successful, and (3) a slowing down of the growth rate of the pathogen within the host so that the growing points and meristems remained uninfected. Since these reactions were constant for any given combination of host and smut, it was possible to classify the examples described into five "grades of resistance" ranging from complete susceptibility to an almost true immunity.

Miss I. M. Wilson. The Asci of *Peziza rutilans* Fries.

Peziza rutilans is a discomycetous fungus in which sexual organs are absent. During the mitotic nuclear divisions in cells at the base of the ascocarp and in the ascogenous hyphae, sixteen chromosomes can be counted. The ascogenous hyphae form croziers, from the binucleate penultimate cell of which the ascus arises. The only nuclear fusion in the life cycle is the one in the young ascus. The first two nuclear divisions in the ascus constitute a meiotic phase. The third division is a mitosis, the sixteen chromosomes splitting longitudinally and sixteen half chromosomes passing to each daughter nucleus. The ascus usually contains eight uninucleate spores, but multinucleate spores and, very occasionally, akaryotic spores also occur.

RULES

Society's Name and Objects

1. The Society shall be called "The British Mycological Society", and its object shall be the study of Mycology in all its branches.

Members of Society

2. The Society shall consist of Honorary Members, Foundation Members, and Ordinary Members; the number of Honorary Members shall be limited to 20, and that of Foundation Members to 100, but the number of Ordinary Members shall be unlimited.

Honorary Members

3. Honorary Members shall be persons of pre-eminence in Mycology, or who have rendered special service to the Society.

Foundation Members

4. Foundation Members shall be those Members or Societies who joined the Society previous to the limit of 100 Members having been attained.*

Officers

5. The Officers of the Society shall consist of a President, one or more Vice-Presidents, Treasurer, Secretaries and Editor or Editors. They shall be elected annually, at the Annual General Meeting of the Society.

Government of Society

6. The government of the Society shall be vested in a Council, which shall consist of the President and other Officers for the time being, together with two or more other Members who shall be elected annually at the General Meeting, and one-half of whom shall retire each year and not be eligible for immediate re-election. The Members to retire shall be those who have been longest in office or, in case of equality, shall be determined by ballot. Ex-Presidents are *ex-officio* Members of the Council.

Every Meeting of the Council shall be duly summoned by the Hon. Secretary by at least seven days' notice in writing to each Member of the Council.

Period of Office

7. The Officers and Council shall hold office as from the 1st of January following their election.

* The limit of 100 Foundation Members was reached 22nd October, 1903.

Plant Pathology Committee

8. The special interests of Plant Pathology shall be delegated to an executive committee, to be called the Plant Pathology Committee of the British Mycological Society. This Committee shall consist of the President and Secretaries *ex-officio* and twelve other members of the Society. The latter shall be elected annually at the Annual General Meeting of the Society, and one-quarter shall retire in rotation each year and shall not be eligible for immediate re-election. The members to retire shall be those who have been longest in office, or, in case of equality, shall be determined by ballot.

The Officers shall consist of a Chairman and a Secretary, to be elected by the Committee each year.

At least two meetings shall be held every year, six members to form a quorum.

The Committee shall have power to appoint for any special purpose a sub-committee consisting either wholly or partly of members of the Committee.

Election of Members

9. Honorary Members shall only be elected at a Meeting of the Society by a majority of the Members then present.

All Ordinary Members shall be proposed and seconded respectively by existing Members, who shall sign a certificate (see Appendix) of recommendation, one at least of the proposers so certifying from personal knowledge. Every candidate for election shall sign an undertaking to abide by the Rules if elected (see Appendix). They shall be elected by a majority of the Members present at any meeting of the Society or by the President and Officers of the Society.

Subscription

10. All Ordinary Members and Societies shall pay an annual subscription of one pound, and Foundation Members five shillings, due on the 1st of January in each year. Honorary Members shall be exempt from any annual subscription.

Any Member wishing to retire from the Society shall give notice to the Hon. Secretary or Treasurer in writing before the 1st of December of the previour year.

Meetings

11. The Society shall hold one or more meetings annually, at a place and time determined by the Members at the preceding Annual General Meeting, or by the Council. The Annual General Meeting, for the election of officers and the transaction of other business, shall coincide with the Autumn Foray.

Accounts

12. At the Annual General Meeting of the Society in each year the Hon. Treasurer shall present duly audited accounts.

Alteration of Rules

13. The Rules shall not be altered except by a two-thirds majority of the Members present at an Annual General Meeting. A printed copy shall be sent to every Member of the Society on election, and in the event of alterations to all Members.

APPENDIX

Form of proposal for Ordinary Membership of the British Mycological Society

of.....

being desirous of becoming an Ordinary Member of the British Mycological Society, we, the undersigned Members of the Society, certify that we consider h to be a desirable Member of the Society, and beg to recommend h for election.

Dated this day of 19

.....(From personal knowledge.)

Certificate to be signed by the Candidate

I hereby certify that I desire to become an Ordinary Member of the British Mycological Society and that I will abide by the Rules if elected.

RECEIPTS AND PAYMENTS FOR THE YEAR ENDING 30 JUNE 1937

1936	£	s.	d.
1 July—Balance brought forward	807	1	1
1937			
30 June—Subscriptions to date	331	16	11
Gifts to Printing Fund	5	7	6
Sale of *Transactions* (direct)	4	11	0
Through Publishers:			
Current vols.	108	17	8
Back vols.	69	11	1
Sale of Reprints	21	12	6
Profit from sale of C. Rea's *British Basidiomycetae*	7	12	5
Deposit Interest	3	5	0
War Loan Interest...	13	4	3
	£1372	19	5

1937	£	s.	d.
30 June—Cambridge University Press, Cost of 450 vol. xx *Transactions* and Reprints ...	439	14	9
Postage, Stationery, etc.	9	0	1
Sundry Printing	3	11	6
Purchase of *Transactions*	4	0	0
Fees of Meetings	4	19	10
Purchase of £200 3½ % War Loan (Printing Fund)	209	9	0
Purchase of £45 3½ % War Loan (Cheesman Fund)	47	3	4
Balance in hand and on deposit	655	0	11
	£1372	19	5

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